Title: COMMUNICATION DEVICE, SUBSEA COMMUNICATION SYSTEM AND MONITORING METHOD FOR A SUBSEA APPLICATION

Abstract: It is described a subsea device, in particular a subsea cable (750), comprising a monitoring node (103, 703), the monitoring node comprising: a monitoring module (107) for monitoring an operating parameter of the subsea device, and a communication interface (111a, 111b) for transmitting information related to the monitored operating parameter.
DESCRIPTION

Communication device, subsea communication system and monitoring method for a subsea application

Field of invention

The present invention relates to a communication device for subsea applications, to a subsea communication system comprising the communication device and to a method for monitoring a communication device during a subsea application.

Art Background

During a subsea application, such as up to 5000 m below sea level, for example for exploring oil and/or gas, a number of operation devices needs to be controlled. For controlling the operation devices, a subsea communication system is required. In typical subsea distribution systems, old communication protocols may still be in use, for example 10 or 100 Mbit Ethernet on copper and fibre, RS422 and CAN-bus technologies. In the commercial market, Gbit Ethernet is the current standard and the increase in required bandwidths is rapidly evolving.

The different devices in a typical subsea application are connected by communication cables which may comprise wires and a hose surrounding the wires that is filled with a dielectric fluid, such as oil, in order to protect the wires from contact to salty deteriorating saltwater. Such cables are also referred to as jumpers in the present application.

Monitoring of the jumpers and subsea distribution channels may be not possible in today’s subsea distribution systems. The conventional subsea communication system or subsea distribution system may consist of passive components like wires
and connectors with no intelligent functionality. In the conventional system, it is very difficult to find an electrical fault or to observe or monitor the performance of a particular jumper. The jumper may be faulty in a number of ways. First, the electrical wires may be faulty in that cross-talk occurs. Further, the hose may not tightly seal the seawater from the wires. The hose may for example comprise leakage sites such that the oil filled within the hose leaks out of the hose, thereby not providing the required protection of the wires, and reduced Insulation resistance (IR) can occur.

Nowadays, with no options for real life monitoring of the hardware in the distribution channel, the subsea distribution system must at least partially be shut-down and disassembled and disconnected for investigation. In the current system it is not possible to localize where a fault occurred and which jumper is affected. For example, it is not possible to identify the particular jumper who has a low insulation resistance (IR).

For troubleshooting, jumpers have to be disconnected by a remotely operated vehicle (ROV) before the IR testing can be performed. Troubleshooting has to continue until the faulty jumper is identified. This is often very time-consuming and very expensive.

Thus, there may be a need for a communication device for subsea application, for a subsea communication system and for a method for monitoring a communication device during a subsea application, wherein a fault can reliably and in a safe manner be monitored in a short time without requiring shut-down of the whole subsea communication system.

Summary of the Invention

The need is solved by the subject-matter of the independent claims. The dependent claims specify particular embodiments of the present invention.
According to an embodiment of the present invention it is provided a subsea device, in particular a subsea cable, comprising a monitoring node, the monitoring node comprising: a monitoring module for monitoring an operating parameter of the subsea device, and a communication interface for transmitting information related to the monitored operating parameter.

The subsea device may be a sensor device, an actuator device or a communication device, in particular a communication cable, or any other subsea device used in a subsea application. The monitoring module may comprise software and/or hardware, in particular one or more sensors, such as electrical and/or optical sensors for monitoring the operating parameter of the subsea device. The operating parameter of the subsea device may in particular indicate whether the (hardware and/or software) state of the subsea device is proper or improper. In particular, the operating parameter may indicate whether a portion of the subsea device is not functioning any more due to, for example, damage.

The communication interface may be a wireless or wire-based communication interface. The information related to the monitored operating parameter may be transmitted, using the communication interface, to a surface facility, in particular via one or more intermediate nodes, a hub or other communication modules. When the subsea device is configured as a subsea cable, the subsea cable may transmit communication signals and/or energy for powering one or more other subsea devices. In particular, when the subsea device is or comprises a subsea cable, the information related to the monitored operating parameter may indicate whether a wire of the subsea cable is damaged or has a failure and may also in particular indicate which of the wires (or optical fibres) has a failure. In particular, the monitoring module may be adapted to sense the integrity of one or more wires of the subsea cable, by detecting whether the one or more wires carry electrical
and/or optical signals. The subsea cable may be configured as an electrical cable and/or an optical cable, comprising one or more optical fibres.

According to an embodiment of the present invention the operating parameter of the subsea device comprises at least one of an insulation resistance of an electrical conductor of the subsea device, an internal pressure of the subsea device, or a change of internal pressure of the subsea device, a water ingress into the subsea device, an operating condition of a communication connection provided in the subsea device, and an operating condition of a subsea connector.

Thereby, manual inspection of the subsea device may not be required any more.

According to an embodiment of the present invention the subsea device comprises a subsea cable including a pressure compensated hose conduit filled with a dielectric liquid or gel.

The pressure compensated hose conduit may, during operation of the subsea device, have an inside pressure (pressure of the dielectric liquid or gel within the hose) which is equal at least approximately equal to an outside pressure, in particular the hydrostatic pressure at a level in the sea (in particular close to a sea bottom) where the subsea device is installed.

According to an embodiment of the present invention the subsea cable includes at least one of at least two electrical conductors disposed in the hose conduit for the transportation of communication signals, and/or at least one optical fiber disposed in the hose conduit for the transportation of communication signals.

The electrical conductor and/or the optical fibre may convey measurement signals or control signals required during a subsea application. The information related to the monitored op-
erating parameters may be transmitted by other means, in particular other electrical conductors and/or optical fibres. Thereby, the subsea application or operation may continue, while the subsea device is monitored, since monitoring the subsea device does not interfere with communicating normal sensor and/or measurement and/or control data necessary for conducting the subsea operation.

According to an embodiment of the present invention the subsea device includes at least one connector at an end of the subsea cable, wherein the connector is preferably a wet-mateable connector. Thereby, connection of the subsea device with one or more other subsea devices is possible, even deep within the sea.

According to an embodiment of the present invention it is provided a communication device for subsea applications, the communication device comprising: first electrical wires for communicating first signals (e.g. between two communication partners below and/or above sea level), a tapping system (in particular including inductive sensing electrical activity in the first wires or wire taps at the first wires) for tapping the first signals, the at least one monitoring module being adapted to receive the tapped first signals, (in particular to deduce a state of the first wires) and to generate monitoring signals representing the information related to the monitored operating parameter at least based on the tapped first signals (in particular and/or based on a state of the wires), and at least one communication interface for controlling communicating the monitoring signals.

The communication device may comprise or be configured as a cable comprising the first electrical wires which are arranged within a hose filled with a dielectric fluid. The communication device may further comprise a connector at one end of the hose and/or another connector at the other end of the hose and the electrical wires.
The subsea application may for example take place at a depth down to 5000 m below sea level. The communication device may for example be located in a range between 0 m and 5000 m below sea level. The communication device may be adapted to withstand the hydrostatic pressure at this depth. The first electrical wires may comprise copper wires for conducting the first signal. The first signals may comprise voltage signal within a range between -30 V and +30 V, or up to 1000V for power.

The first wires may be used in a normal subsea application to transfer power, sensor data or control data to one or more subsea operation devices.

The wire taps may be connections (e.g. at terminals) at the first wires for conveying the first signals to the monitoring module. The monitoring module may for example deduce, to which degree the first electrical wires are insulated from each other or insulated from an electrical ground. The first electrical wires may for example comprise 1 to 20 wires, in particular 12 electrical wires.

For the monitoring, the first signals may be in particular test signals which may allow to deduce the insulation resistance of the first electrical wires from each other or from an electrical ground. In other embodiments, the first signals may represent real sensor signals or other control signals used in the particular subsea application.

The monitoring signal may comprise raw data of the first signals itself or may comprise derived data, such as insulation resistance data. The state of the first wires may depend on other parameters than on the insulation resistance. The state may for example also depend on temperature, lifetime, material of the first wires and so forth.

The monitoring signals are not communicated using the first electrical wires, but using another communication channel.
Thus, even when the monitoring module and/or the communication interface fails, communication of the first signals may continue unaffected. Thereby, a failsafe communication device may be provided.

The communication interface may comprise an electronic card and/or electronic circuit board. The communication interface may support a wire-based and/or wireless communication protocol.

The communication device has the capability of monitoring its own state and includes the required communication equipment to communicate the monitoring signals for example to a topside station, such as a platform above the sea level. Thus, a remotely operated vehicle or shutting down the whole communication system or subsea communication system is not required for detecting a fault and detecting which of the equipment, in particular which communication device, is affected.

According to an embodiment of the present invention, the monitoring module is adapted to deduce at least from the tapped first signals, whether a state of the communication device is faulty, and to generate a warning signal, if the state is faulty.

The state of the communication device may be deduced to be faulty, if one or more criteria are fulfilled. The criteria may be configured depending on the application. The monitoring module may comprise the functionality to generate a warning signal depending on whether configured criteria are fulfilled. Thereby, a large flexibility is provided.

According to an embodiment of the present invention, the monitoring module is adapted to deduce insulation resistance values of the first wires from the tapped first signals, and to generate a warning signal, if at least one of the insulation resistance values decreases below a threshold and/or decreases with a rate higher than a threshold rate.
The insulation resistance value may represent the mutual insulation resistance between respective two of the first wires and/or an electrical ground. In particular embodiments, test signal patterns of the first signals may be imposed in order to derive the insulation resistance value. In other embodiments, the insulation resistance values may be deduced in a normal operation, i.e. involving first signals which represent normal operation signals.

When the insulation resistance value decreases below a threshold, cross-talk may occur or the respective signal(s) may not be reliable any more. In this case, a warning signal is appropriate to be sent to the topside equipment or station in order to have the respective communication device fixed. Also a decrease of the insulation resistance with a rate higher than a threshold rate may indicate that in the near future the respective communication device may not be operating properly any more.

According to an embodiment of the present invention, the communicating the first signals is independent of and/or separate from the communicating the monitoring signals. The first signals may represent control and/or measurement signals required in order to perform the subsea application. When the communication of the monitoring signals is performed independent of the communication of the first signals, the operation of the subsea application may continue, even if the monitoring capability fails. Thereby, the subsea operation may be performed reliably and in a safe manner.

According to an embodiment of the present invention, the communication device further comprises a hose, filled with a dielectric fluid and pressurized, in particular constructed to withstand an inside or outside pressure up to 450 bar, in which the first wires and in particular the second wires are arranged, a pressure sensor for measuring a pressure inside the hose, wherein the monitoring module is further adapted to
receive pressure measuring signals from the pressure sensor and generate the monitoring signals further based on the pressure measurement signals.

The dielectric fluid may for example comprise oil. The hose may be filled with the dielectric fluid such as to compensate the hydrostatic pressure at the location where the hose is arranged below the sea level. The hose together with the dielectric fluid may protect the wires (in particular first electrical wires and second electrical wires) within the hose from corrosion.

The pressure sensor may comprise a conventional pressure sensor which is adapted to measure a pressure up to 500 bar. The monitoring signals thus not only comprise information regarding the state of the wires (for example with respect to their mutual insulation) but may also comprise information regarding a state of the hose, in particular the pressure inside the hose. Thereby, a thorough examination and monitoring of the communication device may be feasible.

According to an embodiment of the present invention, the monitoring module is adapted to generate a warning signal, if a measured pressure inside the hose decreases below a pressure threshold and/or decreases with a rate higher than a pressure threshold rate. If the measured pressure inside the hose decreases below the pressure threshold it may indicate that the desired protection of the wires within the hose may not be longer fulfilled or reliably performed, e.g. due to damage, such as leaks, of the hose. Thus, fixing or replacing the entire communication device or only (a part of) the hose may be indicated.

According to an embodiment of the present invention, the communication device further comprises second electrical wires for transporting the monitoring signals, wherein the communication interface comprises a wire-based communication interface connected to the second electric wires. Thereby, the
monitoring signals may be in a reliable manner transported using the second electrical wires (in particular at least two second electrical wires), in particular to a topside station or platform.

According to an embodiment of the present invention, the communication device further comprises a transceiver adapted to wirelessly transport the monitoring signals and in particular to receive a monitoring request, wherein the communication interface comprises a wireless communication interface connected to control the transceiver.

The wire-based communication interface and the wireless communication interface may both be included within the communication device. In other embodiments, the communication device has only a wire-based communication interface but no wireless communication interface. In still other embodiments, the communication device may have only a wireless communication interface but no wire-based communication interface. Thereby, the communication device may be adapted according to the needs of the particular application.

The transceiver may comprise a transmitter and a receiver for transmitting and receiving, respectively, wireless communication signals. The wireless communication interface and the transceiver may be compliant with for example wireless local area network protocol (WLAN).

In particular situations and configurations it may not be possible to exclusively transfer or convey the monitoring signals using the second electrical wires using a wire-based communication protocol. This may occur for example when the communication device is connected (using a connector) to a subsea equipment which is not prepared or not supporting to forward or guide through the monitoring signals. In this case, the wireless communication interface together with the transceiver may be utilized to nevertheless convey the monitoring signals circumventing the subsea equipment not sup-
porting the wire-based transfer of the monitoring signals, in
order to transfer the monitoring signals for example to an-
other communication device, to a hub module or for example
directly to a subsea distribution module which in turn may
forward the monitoring signals to a topside station or plat-
form. Thus, flexibility in the design of the communication
network is increased.

According to an embodiment of the present invention, the com-
munication device further comprises a canister having an en-
closure surrounded by a sea water tight wall withstanding
high pressure, wherein the wire taps, the monitoring module
and the communication interface are arranged within the en-
closure, the canister in particular being arranged close to
or at one end of the hose.

The canister may also be referred to as a container adapted
for subsea applications. The first electrical wires may partly
be contained within the enclosure of the canister. The
canister may be connected at one end of the hose. At another
end of the hose, another canister having other wire taps, an-
other monitoring module and another communication interface
may be connected.

The canister comprising the wire taps, the monitoring module
and the communication interface may also be referred to as a
monitoring node in the context of the present application.

According to an embodiment of the present invention, the com-
munication device further comprises a connector for connect-
ing the first electrical wires, and in particular also the
second electrical wires, to other equipment, the connector in
particular being wet mateable (or alternatively dry mateable),
the canister in particular being arranged between the con-
necter and the hose.

The connector (such as comprising a plug or a socket) may al-
low to electrically connect the first electrical wires (and
in particular also second electrical wires) to the other equipment. For this, the other equipment may comprise at least a complementary connector (such as a plug or a socket) mateable with the connector. The two connectors may be mateable with each other when localized at a large depth below the sea level. Thereby, the communication device may be utilized for connecting different subsea equipment, in particular, when at each end of the hose and wire a respective connector is provided. Thereby, a subsea communication system or subsea distribution system may be easily assembled.

According to an embodiment of the present invention, the communication interface, in particular complying to Ethernet, further in particular complying to SMNP, is adapted to receive a monitoring request and to transmit a monitoring answer via the monitoring signals, wherein the communication interface has a network address, in particular an IP-address. The communication interface may for example receive a monitoring request from the topside station or platform asking for monitoring signals for a particular communication device which may be identified by the network address. Using the second electrical wires and/or the wireless interface, the communication device may send a monitoring answer comprising identification information of the communication device and further comprising the monitoring signals, in particular regarding the insulation resistance and/or pressure within the hose. The monitoring answer may comprise raw measurement data of the pressure sensor and the insulation resistance and/or may comprise state data being derived by analyzing the raw measurement data of the pressure sensor and/or the insulation resistance values. The network address may be unique within an entire subsea communication system for unambiguously identifying the respective communication device.

According to an embodiment of the present invention it is provided a subsea communication system, comprising a topside station installed above sea level, a subsea distribution unit installed in the sea and communicatively connected to the
topside station, in particular via an optical fiber (or alternatively copper), a communication device according to one of the preceding claims connected at one end to the subsea distribution system, wherein the subsea distribution unit is configured to forward the monitoring signals received, wire-based (or at least partially wirelessly), from the communication device to the topside station.

The topside station may be or comprise a platform in the sea. The subsea distribution unit may be adapted to be, on one hand, connected to the topside station and on the other hand, be connected to plural subsea electrical modules which may in turn be connected to plural sensor devices or other operational devices required during the subsea exploration. The subsea distribution unit may advantageously distribute control signals sent from the topside station to the plural subsea electrical modules. On the other hand, the subsea distribution unit may receive from the plural subsea distribution modules monitoring signals and also operation signals (comprised in the first signals) and forward these in an ordered manner to the topside station. Thereby, the subsea distribution unit, conventionally provided for forwarding control signals from the topside station to the plural subsea operation devices and receiving measurement values of the plural operation devices, such as sensors, and forwarding the measurement signals to the topside station, in addition may be utilized for forwarding the monitoring signals from the plural communication devices to the topside station. Thus, no additional equipment may be required in order to transfer the monitoring signals. Thereby, costs of the subsea communication system may be limited.

According to an embodiment of the present invention, the subsea communication system further comprises a (or at least one) hub module adapted to wirelessly receive the monitoring signals from the communication device and to wire-based transmit the monitoring signals to the subsea distribution unit.
In the case the subsea distribution unit is not prepared to support or handle the monitoring signals in a wire-based manner, the hub module may be utilized which may advantageously receive the monitoring signals wirelessly from the communication device (or in particular plural communication devices connected to the subsea distribution unit), convert the wireless signals into wire-based signals and then feed the wire-based signals, i.e. electrical signals, to the subsea distribution unit, in particular using a particular input port or input channel being separate from the wire-based connections of the plural communication devices to the subsea distribution system.

According to an embodiment of the present invention, the subsea communication system further comprises a subsea electrical module, wherein the communication device is connected at the other end to the subsea electrical module. Thus, the communication device connects the subsea distribution unit with a subsea electrical module. In fact, plural communication devices may be provided that connect on one hand the subsea distribution unit with on the other hand plural subsea electrical modules.

According to an embodiment of the present invention, the subsea communication system further comprises an operation device (such as a sensor device) for a subsea exploration, another communication device according to one of the preceding claims connected between the operation device and the subsea electrical module, wherein the other communication device communicates operation signals of the operation device as the first signals wire-based to the subsea electrical module, wherein the other communication device wirelessly or wire-based (using the second wires) communicates its monitoring signals to the communication device.

The operation device may for example be an actuator, such as a pump, a compressor, or the like or may comprise a measure-
ment device, such as a pressure sensor, a flow rate meter or the like. Thereby, the communication device may be utilized for communicatively connecting different types of subsea equipment. Thereby, it is not required to provide different connection equipment for different subsea devices, thereby, reducing costs. The operation signals of the operation device are (comprised in) the first signals which are transferred using the first electrical wires. When the subsea electrical module supports wire-based forwarding of the monitoring signals, the other communication device may communicate its monitoring signals to the communication device using its first wires and feeding its monitoring signals using the second wires to the subsea electrical module which in turn forwards the monitoring signals of the other communication device to the second wires of the communication device.

If the subsea electrical module does not support forwarding the monitoring signals of the other communication device to the communication device, the other communication device may wirelessly communicate its monitoring signals to the communi-
cation device (which also has a wireless communication inter-
face). Thereby, a large flexibility is provided.

According to an embodiment of the present invention, the op-
eration device is a sensor device for measuring a physical property, in particular pressure or flow rate of gas and/or oil exploited and/or conveyed in a subsea operation, wherein the operation signals comprise sensor signals of the sensor device.

The sensor device may be a conventional sensor device uti-
lized in a conventional subsea exploration. In other embodi-
ments, the operation device may be an actuator, such as a pump, a compressor or the like and the first signals may com-
prise control signals in order to control the actuation of the actuator device, such as to control the pump rate or the compression properties.
According to an embodiment of the present invention, the subsea communication further comprises another hub module configured to receive the wirelessly transmitted monitoring signals of the other communication device and to transfer the monitoring signals via the communication device and the subsea distribution unit to the topside station. The other hub module may not be present in all embodiments. It may however be advantageous, if the local environment does not allow to wirelessly transmit the monitoring signals of the other communication device to the communication device, e.g. due to an obstacle or difficulties for generating or receiving the wireless signals. The other hub module may be placed such as to be able to receive the monitoring signals from the other communication device. Thereby, a large flexibility is provided.

According to an embodiment of the present invention, the subsea communication system further comprises an optical fiber (or metal cables, such as copper cables) connected to the topside station, a optical/electrical converter connected to the subsea distribution unit and to the optical fiber and adapted to convert electrical communication signals to optical communication signals and vice versa.

The optical fiber may in an effective manner convey plural communication signals from the topside to the subsea distribution unit and vice versa, for example using multiplexing technologies. Thereby, bandwidth may be increased and costs may be reduced.

It should be understood that features which have been individually or in any combination disclosed with respect to the communication device or the subsea communication system may also be, individually or in any combination, provided to a method for monitoring a communication device during a subsea application according to an embodiment of the present invention and vice versa.
According to an embodiment of the present invention it is provided a method for monitoring a subsea device, in particular a subsea cable, the method comprising monitoring an operating parameter of the subsea device, and transmitting information related to the monitored operating parameter.

The method may further comprise communicating, using first electrical wires of the subsea device, first signals, tapping, at the subsea device, the first wires, deducing, at the subsea device, a state of the first wires, generating, at the subsea device, monitoring signals at least based on the state of the first wires, the monitoring signals representing the information related to the monitored operating parameter, controlling, at the subsea device, communicating the monitoring signals.

According to an embodiment of the present invention it is provided a method for monitoring a communication device during a subsea application, the method comprising: communicating, using first electrical wires of the communication device, first signals; tapping, at the communication device, the first wires; optionally deducing, at the communication device, a state of the first wires; generating, at the communication device, monitoring signals at least based on the first signals and/or a state of the wires; controlling, at the communication device, communicating the monitoring signals.

It has to be noted that embodiments of the invention have been described with reference to different subject matters. In particular, some embodiments have been described with reference to method type claims whereas other embodiments have been described with reference to apparatus type claims. However, a person skilled in the art will gather from the above and the following description that, unless other notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters, in particular between...
features of the method type claims and features of the apparatus type claims is considered as to be disclosed with this document.

The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

The following clauses are included in the present disclosure, their features being combinable with features of embodiments described above and below in the detailed description and vice versa:

Clause 1. A subsea device, in particular a subsea cable, comprising

- a monitoring node, wherein the monitoring node comprises at least one monitoring interface for monitoring an operating parameter of the subsea device, and a further comprises a communication interface for transmitting information related to the monitored operating parameter.

Clause 2. The subsea device according to clause 1, wherein the operating parameter of the subsea device comprises at least one of an insulation resistance of an electrical conductor of the subsea device, an internal pressure of the subsea device, or a change of internal pressure of the subsea device, a water ingress into the subsea device, an operating condition of a communication connection provided in the subsea device, and an operating condition of a subsea connector.

Clause 3. The subsea device according to clause 1 or 2, wherein the monitoring node comprises at least two monitoring interfaces, wherein a pressure sensor is connected to one of the monitoring interfaces and wherein circuitry for monitor-
ing the insulation resistance of an electrical conductor of
the subsea device is connected to another of the monitoring
interfaces.

Clause 4. The subsea device according to any of the preceding
clauses, wherein the subsea device is a subsea cable includ-
ing at least two electrical conductors for the transportation
of electrical power.

Clause 5. The subsea device according to any of the preceding
clauses, wherein the subsea device is a subsea cable includ-
ing a pressure compensated hose conduit filled with a dielec-
tric liquid or gel, wherein two or more electrical conductors
are disposed in the hose conduit.

Clause 6. The subsea device according to any of the preceding
clauses, wherein the subsea device is a subsea cable includ-
ing at least two electrical conductors for the transportation
of communication signals, and/or including at least one opti-
cal fiber for the transportation of communication signals.

Clause 7. The subsea device according to any of the preceding
clauses, wherein the subsea device is a subsea cable includ-
ing at least one connector at an end of the subsea cable,
wherein the connector is preferably a wet-mateable connector.

Clause 8. The subsea device according to any of the preceding
clauses, wherein the communication interface is an electrical
communication interface to which one or more, preferably two,
electrical conductors are connected for data communication,
or wherein the communication interface is a wireless communi-
cation interface providing wireless data communication.

Clause 9. The subsea device according to any of the preceding
clauses, wherein the monitoring node includes an electronic
assembly, in particular a printed circuit board assembly,
providing said at least one monitoring interface and said
communication interface.
Clause 10. The subsea device according to any of the preceding clauses, wherein the subsea device comprises a subsea enclosure in which the electronic assembly is disposed, wherein the subsea enclosure is a pressure resistant enclosure maintaining a predefined internal pressure when installed subsea, or is a pressure compensated enclosure the internal pressure of which is balanced to a surrounding seawater pressure when installed subsea, wherein preferably, the subsea device is a subsea cable and the subsea enclosure is mounted at an end of the subsea cable, in particular in association with a subsea connector.

Clause 11. The subsea device according to any of the preceding clauses, wherein the monitoring node is configured to use a dedicated monitoring communication connection on the communication interface that is separate from a data transmission line provided by the subsea device, in particular a subsea cable, for data transmission.

Clause 12. The subsea device according to any of the preceding clauses, wherein the communication interface of the monitoring node is configured to establish an Ethernet connection, and/or is configured to employ an SNMP (simple network management protocol) communication protocol for data communication.

Clause 13. The subsea device according to any of the preceding clauses, wherein the monitoring node is configured to issue a warning signal on the communication interface upon occurrence of a predetermined condition of a monitored operating parameter, in particular upon a predetermined change of a monitored insulation resistance and/or a predetermined change of a monitored internal pressure of the subsea device.

Clause 14. The subsea device according to any of the preceding clauses, wherein the monitoring node is configured to al-
low an identification of the subsea device, wherein preferably, each monitoring node has an IP address.

Clause 15. The subsea device according to any of the preceding clauses, wherein the monitoring node is configured to receive electrical power through the communication interface, and/or further comprises a power input for receiving electrical power via an electrical connection of the subsea device.

Clause 16. A subsea monitoring hub, comprising

- one or more first communication interfaces for communication with one or more monitoring nodes of respective subsea devices that are configured in accordance with any of the preceding clauses, and
- at least one topside communication interface for communication with a topside installation.

Clause 17. The subsea monitoring hub according to clause 16, wherein at least one of said first communication interfaces comprises an interface configured to establish a wireless connection for data communication to a monitoring node of a subsea device according to any of the preceding clauses.

Clause 18. The subsea monitoring hub according to clause 16 or 17, wherein the at least one topside communication interface is configured to establish a wired or wireless connection to a subsea distribution unit (SDU) that is in communication with the topside installation.

Clause 19. The subsea monitoring hub according to any of clauses 16-18, wherein the subsea monitoring hub is configured to receive monitoring signals indicative of a monitored operating parameter from one or more monitoring nodes via the one or more first communication interfaces, and to process the received monitoring signals, in particular to determine whether a predetermined condition exists for a monitored op-
erating parameter and to issue a warning signal in the af-
firmative.

Clause 20. The subsea monitoring hub according to any of
clauses 16-19, wherein the subsea monitoring hub comprises a
processing unit providing said one or more first communica-
tion interfaces and said topside communication interface,
and/or wherein the subsea monitoring hub comprises a subsea
enclosure configured to allow deployment of the subsea moni-
toring hub at a subsea installation.

Clause 21. The subsea monitoring hub according to any of
clauses 16-20, wherein the subsea monitoring hub comprises a
electrical power connection for the supply of electrical pow-
er to a subsea electronics module (SEM), to a subsea distri-
bution module (SDU) or to a topside installation.

Clause 22. The subsea device according to any of clauses 1-15
or the subsea monitoring hub according to any of clauses 16-
21, wherein the communication interface of the monitoring
node and/or the topside communication interface of the subsea
monitoring hub is configured to operate using a SIIS level 3
compliant communication method, in particular Ethernet commu-
nication.

Clause 23. A subsea monitoring system for monitoring an oper-
ating parameter of one or more subsea devices, comprising:

- at least one subsea device according to any of clauses
  1-15,
- at least one subsea monitoring hub according to any of
  clauses 16-22,
- a communication link between the communication interface
  of the monitoring node of the subsea device and a first
  communication interface of the subsea monitoring hub, and
- a topside communication link between the topside communication interface of the subsea monitoring hub and the topside installation.

Clause 24. The subsea monitoring system according to clause 23, wherein the topside communication link includes a subsea installed media converter converting between an electrical data communication signal and an optical communication signal, and further includes a fiber optic data connection between the media converter and the topside installation.

Clause 25. The subsea monitoring system according to clause 23 or 24, wherein the subsea monitoring hub is implemented in a subsea distribution unit, or wherein the subsea monitoring hub is a separate unit in communication with a subsea distribution unit.

Clause 26. The subsea monitoring system according to any of clauses 23-25, wherein the subsea monitoring system comprises a subsea device in form of a first subsea cable, wherein the subsea cable comprises one, preferably two, monitoring nodes, the communication link between the monitoring nodes of the subsea cable and the subsea monitoring hub being separate from power transmission and/or communication transmission lines of the subsea cable.

Clause 27. The subsea monitoring system according to any of clauses 23-26, wherein the subsea monitoring system comprises a subsea device in form of a first subsea cable and a subsea device in form of a second subsea cable, wherein a subsea module, in particular a subsea control module (SCM) or a subsea electronic module (SEM) is connected in series between the two subsea cables, wherein a communication link is established between the monitoring node of the first subsea cable and the monitoring node of the second subsea cable, the communication link being a wired link via the subsea module or a wireless link.
Clause 28. The subsea monitoring system according to any of clauses 23-27, wherein the subsea monitoring system comprises a subsea distribution unit providing the topside communication link, an further comprises a subsea device in form of a subsea cable connected to the subsea distribution unit, wherein the monitoring node of the subsea cable is in communication with the topside installation via the subsea distribution unit.

Clause 29. The subsea monitoring system according to any of clauses 23-28, further comprising a second subsea monitoring hub, wherein the communication link between the communication interface of the monitoring node of the subsea device and the first communication interface of the first subsea monitoring hub includes the second subsea monitoring hub and preferably comprises a wireless connection between the monitoring node and the second monitoring hub, and a wired connection between the second monitoring hub and the first monitoring hub.

Clause 30. The subsea monitoring system according to any of clauses 23-29, wherein the at least one subsea device includes a subsea device selected from the group comprising a subsea cable connected between a subsea control module and a sensor, a subsea cable connected between a subsea distribution unit and a subsea control module, and a subsea cable connected between a subsea monitoring hub and a subsea distribution unit or subsea control module.

Clause 31. The subsea monitoring system according to any of clauses 23-30, comprising at least four subsea devices in form of at least two subsea cables connected between a subsea distribution unit and two subsea control modules, and two subsea cables connected between a respective subsea control module and a further subsea device.
Brief Description of the Drawings

The invention will now be described with reference to the accompanying drawings. The invention is not restricted to the illustrated or described embodiments.

Fig. 1 schematically illustrates a communication device according to an embodiment of the present invention;

Fig. 2 schematically illustrates a communication device according to an embodiment of the present invention;

Fig. 3 schematically illustrates a communication device according to an embodiment of the present invention connected to further equipment;

Fig. 4 schematically illustrates the SIIS level 3 interface used according to an embodiment of the present invention in the communication device as illustrated in Figs. 1, 2 or 3;

Fig. 5 schematically illustrates a subsea communication system according to an embodiment of the present invention involving or comprising plural communication devices according to embodiments of the present invention;

Fig. 6 schematically illustrates a hub module as is included in the subsea communication system illustrated in Fig. 5 according to an embodiment of the present invention; and

Fig. 7 schematically illustrates a subsea communication system, in particular subsea monitoring system, according to an embodiment of the present invention.

Detailed Description

The illustration in the drawings is in schematic form. It is noted that in different figures, similar or identical ele-
ments are provided with the same reference signs or with reference signs, which are different from the corresponding reference signs only within the first digit.

The communication device 100 illustrated schematically in Fig. 1 comprises first wires 101 for communicating first signals 102. The first signals 102 may for example comprise operation signals as used in a typical subsea operation. The first signals 012 may for example include sensor signals of a subsea sensor, such as a pressure sensor, a flow rate sensor or the like. In other embodiments, the first signals may comprise control signals for controlling a subsea device, such as a pump, a compressor or the like.

The communication device 100 further comprises a monitoring node 103 for monitoring at least the state of the first wires 101. The monitoring node 103 comprises wire taps 105 at the first wires 101 for tapping the first signals 102. The first signals 102 may run in the direction from left to right or from right to left. The monitoring node 103 further comprises a monitoring module 107 which is adapted to receive the tapped first signals 102, (in particular to deduce a state of the first wires 101) and to generate monitoring signals 109 which are based at least on the tapped first signals 102 and/or the deduced state of the wires 101. The monitoring node 103 further comprises a communication interface 111 for controlling communicating the monitoring signals 109. The communication interface 111 may include a wire-based communication interface 111a and/or a wireless communication interface 111b, as is illustrated in Fig. 1. The wire-based communication interface 111a receives the monitoring signals 109 from the monitoring module 107 and communicates the monitoring signals 109 using second wires 113. In the illustrated embodiment, there are exactly two second wires 113 for communicating the monitoring signals 109 using the wire-based communication interface 111a.
In the embodiment illustrated in Fig. 1, the communication of the first signals 102 complies with the SIIS level 3 communication technology. Herein, 12 pins are available from which the pins 1, 2, 5, 6, 7, 8, 9, 10, 11, 12 are used for communicating the first signals 102 using the first wires 101. The pin numbers 3 and 4 are optional pins not required to support the SIIS level 3 communication. These two pins 3 and 4 are used for communicating the monitoring signals 109. The second wires 113 are those which are connected to the pin numbers 3 and 4.

The communication device 100 illustrated in Fig. 1 further comprises a hose 115 filled with a dielectric fluid 117 (for example oil) and pressurized in order to compensate the hydrostatic pressure of the seawater 119 surrounding the communication device when used in a subsea exploration. The hose 115 houses the first wires 101 and the second wires 113 and protects them from contact with seawater 119, thereby adding a second barrier of insulation of the first wires 101 and the second wires 113.

Furthermore, the communication device 100 (in particular the monitoring node 103) comprises a pressure sensor 121 for measuring a pressure inside the hose 115. Thereby, the monitoring module 107 is further adapted to receive pressure measuring signals 123 from the pressure sensor 121 and to generate the monitoring signals 109 further based on the pressure measurement signals 123. The monitoring signals 109 may for example successively include the signals characterizing the state of the first wires 101 and also including the pressure measurement signals 123. The monitoring signals 109 may also be assembled by the monitoring module 107 to respond to a monitoring request 125 which may have been received via the second wires 113 or wirelessly using the wireless communication interface 111b.

The monitoring module 107 or the communication interface 111 (such as wire-based communication interface 111a or wireless
communication interface 111b) may comprise an identification token (e.g. stored in an electronic storage), such as a network address, in particular IP-address for unambiguously identifying the communication device 100 within a subsea communication network. The monitoring signals 109 (or signals derived therefrom and sent by the interface 111a and/or 111b) may thus also comprise address information such that a receiver of the monitoring signals 109 obtains information regarding the identity of the communication device, the pressure signals or state signals of the first wires refers to.

The wireless communication interface 111b uses a not illustrated transceiver to wirelessly receive and transmit signals, such as a monitoring request and monitoring response.

The communication device 100 further comprises a canister 127 having an enclosure 129 surrounded by seawater tight wall 131 withstanding high pressure (such as up to 450 bar). Thereby, the wire taps 105, the monitoring module 107 and the communication interface 111a, 111b are arranged within the enclosure 129. Thus, in particular, the monitoring node 103 is enclosed within (or comprises) the canister 127 for protecting the monitoring node. The enclosure is further filled with the dielectric fluid 117 which also fills the inside of the hose 115. Thereby, the enclosure 117 is (in communication with) connected with the inside of the hose 115, thus within the enclosure 129 the same pressure of the dielectric fluid prevails as inside the hose 115. The canister is arranged close to an end of the hose 115.

The communication device 100 further comprises a connector 133 for connecting the first electrical wires 101 and also the second electrical wires 113 to other equipment. The connector 133 may for example be formed as a plug or a socket having a standard configuration compliant e.g. with the SIIS level 3 interface. As can be seen from Fig. 1, the canister 127 comprising the monitoring node 103 is arranged between the connector 133 and the hose 115.
This configuration as illustrated in figure 1 is based on the same principles as the standard configuration illustrated in Fig. 4 below. The difference or addition is the possibility to have a more detailed monitoring of the connector and wires through wiretapping. The full configuration can also send wirelessly. In the example of figure 1, one monitoring node is added in the jumper. Additional modules are added to interface wiretapping of the Ethernet signals and power. In addition a Pressure sensor (PT) is added to monitor sealing performance of the jumper assembly.

The communication device 100 illustrated in Fig. 1 may comprise extended first wires 101, second wires 113 and an extended hose 115 extending to the right of Fig. 1. At another end of the communication 100 not illustrated in Fig. 1, the communication device may additionally comprise another canister 127 in which another monitoring node 103 is arranged and may further comprise another connector 133 for connecting the communication device 100 to other equipment. Fig. 2 illustrates such an arrangement of a communication device 200 comprising a hose 215 in which the not illustrated first wires, and second wires are arranged and wherein the hose 215 is filled with pressurized dielectric fluid. At both ends of the hose comprising the wires, the communication device 200 comprises respective canisters 227 containing respective monitoring nodes. At both ends of the communication device, connectors 233 are arranged in order to connect both ends of the communication device with other equipment.

The communication device 100, 200, also preliminarily called I-jumper, may comprise standard subsea wet mateable connectors or sensors, hose conduit with small canisters (subsea enclosures) containing a monitoring node 103 (comprising electronics) in each end (PCBA). The monitoring node 103 is for monitoring of pressure and IR of the jumper. The monitoring node 103 can be installed in a pressure compensated hose with silicon oil. The monitoring node 103 integrated into the communication channel can support the current protocol (SIIS
level 1, 2 and 3), and communicate with the application specific equipment (could be subsea or topside).

The communication device 200 may use Ethernet communication to monitor the wiring condition included connector(s) and sensors. The communication device is monitored with Ethernet signals, typical SNMP. It will be possible to communicate with the communication device from topside trough the I-Grid System. The communication device will give a warning if a fault is occurring subsea. This will ease operation and reduce cost in finding the failure subsea, which is a problem today. The Ethernet signal is only for monitoring the communication device and is in addition to the signal in the jumper specified by the customer. The monitoring signal can be wired trough connector pins to the next connection, or it can send signals wireless to avoid using two pins in the connector. Together with the I-Hub, wireless communication can be obtained without interfering existing SEM modules communication.

In Fig. 3, a configuration of a communication device 300 is depicted, wherein the communication device comprises a hose 315, canisters 327 arranged and connected at both ends of the communication device, wherein the canisters 327 contain respective monitoring nodes. The communication device 300 has only on one end a connector 333 connected. At the other end, the communication device has other equipment 335, such as operation device or sensor 562, connected, such as a sensor or the like. Other configurations of the communication device are possible.

Power supply of the monitoring node may e.g. support input voltage range 230-690 VAC, and/or 12-48 VDC. Maximum power consumptions should not exceed 1 W, size of the housing shall not exceed an outer diameter of 89 mm. The monitoring node may have interfaces for sensor connection, may log two times per day in monitoring mode, shall be able to do continuous
monitoring during trouble shooting mode, wire size may be AWG 22-24.

Fig. 4 illustrates the signal transfer via the 12 pins, based on which the communication device may be configured. The configuration may be based on adding monitoring nodes (electronics) with IP addresses as part of the jumpers or junction boxes and a pressure sensor. To be able to communicate with the electronics, two wires (i.e. the second wires) have to be allocated for the purpose of sending the monitoring signals. As a result, only 10 contacts will be available in a 12-way connector. For a typical Ethernet jumper or distribution channel, SIIS level 3 can be referred. To be compliant with the SIIS connector interface, the allocated monitoring wires have to be connected to contact 3 and 4. With this configuration it may be possible to monitor and communicate with the jumper and monitor the pressure in the jumper. It may not be possible to go further down at the jumper level, e.g. to monitor status of the remaining contacts/wires. The intention with this configuration may be to get an indication of the jumper status and internal pressure in the hose.

Fig. 5 schematically illustrates a subsea communication system 550 (also preliminarily called I-grid) according to an embodiment of the present invention comprising plural communication devices 500 each having at least one monitoring node 503. The subsea communication system 550 comprises a topside station 551 for example situated on a platform. The topside station 551 is above the sea level 553. An umbilical fiber or metal wire 555 leads from the topside station 551 to a optical/electrical converter 557 which converts optical signals 563 transferred using the optical fiber 555 to electrical signals. The electrical signals are provided to a subsea distribution unit 559.

Signals 561 and signals 563 may be communicated from or to the topside station 551 to or from the subsea distribution unit 559. The signals 561 may for example comprise measure-
ment signals obtained from sensor devices 562 used in a subsea exploration. Additionally, the signals 561 may comprise monitoring signals 509 transferred from the monitoring nodes 503 to the subsea distribution unit 559. Thereby, the monitoring signals 509 may partly be transferred wire-based or/and partly transferred wirelessly, depending on the configuration of the subsea communication system 550.

The monitoring signals 509 from different monitoring nodes 503 are distinguished based on a network address of the plural monitoring nodes 503, the network address being included in the monitoring signals. Thus, the monitoring signals 509 illustrated in Fig. 5 are not all the same monitoring signals but may be different monitoring signals associated with the respective monitoring nodes from which they originated.

The monitoring nodes 503 arranged in close proximity to the subsea distribution unit for example transmit their monitoring signals 509 and also monitoring signals received from other monitoring nodes wirelessly to a hub module 565 which forwards the monitoring signals 509 wire-based to the subsea distribution unit 559 which in turn transfers them via the optical/electrical converter 557 and the optical fiber 555 to the topside station 551. The subsea distribution unit 559 is, via plural communication devices 500, connected to plural subsea electrical modules 567. The subsea electrical modules 567 control subsea operation devices 562, such as sensor devices. Thereby, the subsea electrical modules 567 are connected, via further communication devices 500 also comprising monitoring nodes 503 to the operation devices 562.

Since the subsea electrical module 567 typically does not support forwarding the monitoring signals wire-based using the second wires 113 (illustrated in Fig. 1), the monitoring signals 509 may be transferred from the monitoring nodes 503 arranged in close proximity to the subsea electrical module wirelessly to further hub module 565b. The further hub module 565b is connected, via a further communication device 500 al-
so harboring monitoring nodes 503 to the subsea distribution unit 559. In the case the monitoring signals 509 are transferred to a hub module 565b, the respective subsea electrical module 567 can be connected to the subsea distribution unit via a conventional jumper or communication device 569 not comprising monitoring nodes.

The operation device 562 communicates operation signals 102 using the first wires as the first signals 102. The monitoring signals 509 are transferred using the second wires of the communication device 500 connected between the operation device 562 and the subsea electrical module 567.

The hub module 565b illustrated in Fig. 5 may not be in all situations necessary for communicating the monitoring signals 509. In situations, where no obstacles prohibit sending the monitoring signals wirelessly around or circumventing the subsea electrical module 567, the hub module 565b may be dispensed with. In this case, the monitoring signals 509 may be wirelessly transmitted from one monitoring node 503 of a communication device 500 connected between an operation device and the subsea electrical module 567 to a monitoring node 503 of another communication device 500 connected between the subsea electrical module 567 and the subsea distribution unit 559.

The subsea communication system 550 may perform a method for monitoring a communication device 500 during a subsea application according to an embodiment of the present invention. One of the communication devices 500 may communicate, using first electrical wires 101, of the communication device 500, first signals 102. Further, the first wires may be tapped at the communication device 500. Furthermore, a state of the first wires 101 may be deduced at the communication device 500. Further, at the communication device, monitoring signals 509 at least based on the state of the wires 101 may be generated. Finally, communicating the monitoring signals 509 may be controlled at the communication device 500.
The communication devices illustrated in Figs. 1, 2 and 3 may be configured to perform the monitoring method according to an embodiment of the present invention.

The idea of the I-Grid may be to implement intelligent electronics like routers, switches or nodes as part of the distribution system (SIL compliant). The implementation of smart devices into the communication channel (e.g. jumpers, junction boxes etc), may give the user the advantage of continuous monitoring of all segments of a distribution system. The I-Grid System communicates from the topside to the subsea network elements with signals separated from the production signal. The system is fail safe, meaning that if the I-Grid system fails, normal production signal will not be affected. The communication may be by SMNP, and each node, in particular monitoring node, may have its own IP address. In addition the I-Grid monitors the internal oil pressure in the jumper and IR of the wires for the production signals. Logging of pressure sensor can be used for monitoring of jumper pressure reduction, an indication of water ingress. If IR values starts to drop, the I-Grid system will send an early warning topside that the jumper needs to be replaced within next service operation in the field.

The I-Grid may have communication with topside or control system. Two wires power and communicate with the nodes. Each monitoring node has address for identification. Alternatively can wireless communication based on current SIEMENS Subsea technology be used. With wireless communication, conductive pins in the connector are not used. If the SEM (Subsea Electrical Module) is not a Siemens product, it may not be possible to wire the I-Grid the SEM due to conductor pin configuration and handling of the I-Grid signal. The I-Jumper bypasses the SEM with wireless communication. If steel structures and distance between jumpers on the seabed to the I-Hub blocks the wireless signal, I-Hubs on the SCM (subsea control module) may be added to strengthen the signal. Design and
placing of the SCM will affect how many I-Hubs are needed to ensure high quality of the wireless signal. The I-Hub will convert the signals to wire, and send them to the SDU. From the SDU to topside through the umbilical, the copper I-Grid signal will be converted to fiber optical signal by use of a media converter.

Fig. 6 schematically illustrates a hub module 565 which may be used within the subsea communication system illustrated in Fig. 5. The hub module 565 may for example be configured as follows:

Communication can be communicated transparent on current system communication protocol. Alternatives are to use wireless (or wired) communication or modulated onto current signals. A complete insulated monitoring system can be designed based on monitoring nodes and sensors inside the communication device, 100, 200, 300, 565. The monitoring nodes will communicate with other nodes, either hardwired or wireless. The control and monitoring will be handled in one or several hubs 565, 565b which communicate with topside. With the design of master Hub 565, slave hubs 500 and communication devices 100, 200, 300 a full subsea distribution monitoring system can be made. Communication will be based on wired and wireless communication. Power will be taken from existing power supply lines in the channel, or alternatively from power source completely insulated from the operational system.

An exemplary configuration of the hub 565 may include the following:
- Max power consumption for I-hub may not exceed 100 W
- May have SIL level 3 for SEM communication
- May be powered by SEM
- May be option for stand alone with power from topside
- May have option for stand alone communication to topside
- May be able to communicate wireless with nodes
- Shall be able to store logfiles
Fig. 7 schematically illustrates a subsea communication system, in particular subsea monitoring system 700, according to an embodiment of the present invention. The subsea communication system 700 is also referred to as I-grid. The subsea communication system 700 comprises a subsea device 750 according to an embodiment of the present invention. Further, the subsea communication system 700 comprises a topside station 751.

The subsea device 750 may be any type of subsea device, such as a subsea control module, a sensor module or an actuator module. The subsea device 750 comprises a monitoring node 703 which includes a not illustrated monitoring module and a communication interface. Using the monitoring interface, the monitoring node 703 is enabled, for example, to monitor the insulation resistance of a conductor of a subsea cable 750 or a pressure inside the subsea cable 750 or inside the subsea device 780.

The subsea communication system 700 further comprises a subsea distribution unit 759 (also referred to as subsea monitoring hub) which provides data communication capability with the topside installation 751. The subsea distribution unit 759 is also referred to as I-hub. In other embodiments, the subsea distribution unit 759 may provide communication between another subsea distribution unit 759 and a monitoring node. The subsea distribution unit may for example be used to extend wireless data communication with the monitoring nodes or to provide data communication for monitoring nodes 703 to which a connection would otherwise be difficult.

By means of the monitoring node 703, a malfunction of the associated subsea device 750, 780 can be detected. In particular, it can be detected which subsea device 750, 780 is malfunctioning or damaged (possibly damage hose 715 in which wire 701 is enclosed, or damaged connector 733) and an early warning may be transmitted e.g. to the topside facility 751.
so that the malfunctioning subsea device may be repaired, exchanged or fixed. For example, the monitoring node 703 may be adapted to monitor for example the insulation resistance (IR) of the subsea cable 750 or may be adapted to monitor its internal pressure when the subsea cable 750 is provided as a pressure compensated oil filled hose.

It should be noted that the term "comprising" does not exclude other elements or steps and "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.
CLAIMS:

1. Subsea device, in particular a subsea cable (750), comprising a monitoring node (103, 703), the monitoring node comprising:
   - a monitoring module (107) for monitoring an operating parameter of the subsea device, and
   - a communication interface (111a, 111b) for transmitting information related to the monitored operating parameter.

2. Subsea device according to claim 1, wherein the operating parameter of the subsea device comprises at least one of an insulation resistance of an electrical conductor of the subsea device, an internal pressure of the subsea device, or a change of internal pressure of the subsea device, a water ingress into the subsea device, an operating condition of a communication connection provided in the subsea device, and an operating condition of a subsea connector.

3. Subsea device according to any of the preceding claims, wherein the subsea device comprises a subsea cable (750) including a pressure compensated hose conduit (115, 715) filled with a dielectric liquid or gel.

4. Subsea device according to the preceding claim, wherein the subsea cable includes at least one of:
   - at least two electrical conductors (101, 701, 113) disposed in the hose conduit (115, 715) for the transportation of communication signals, and/or
   - at least one optical fiber disposed in the hose conduit for the transportation of communication signals.

5. Subsea device according to any of the preceding claims 3 or 4, including at least one connector (133, 733) at an end of the subsea cable, wherein the connector is preferably a wet-mateable connector.
6. Subsea device according to any of the preceding claims 3 to 5, further comprising:
   first electrical wires (101) for communicating first
   signals (102);
   a tapping system for tapping the first signals (102),
   wherein the monitoring module (107) is adapted to re-
   ceive the tapped first signals (102) and to generate monitor-
   ing signals (109) representing the information related to the
   monitored operating parameter at least based on the tapped
   first signals;
   wherein the communication interface (111a, 111b) is
   adapted to control communicating the monitoring signals
   (109).

7. Subsea device according to the preceding claim, wherein
   the tapping system comprises wire taps (105) at the first
   wires (101) for tapping the first signals (102).

8. Subsea device according to one of the preceding claims 6
   or 7, wherein the monitoring module (107) is adapted to de-
   duce at least from the tapped first signals (102), whether a
   state of the subsea device (100) is faulty.

9. Subsea device according to the preceding claim, which is
   adapted to generate a warning signal, if the state is faulty.

10. Subsea device according to one of the preceding claims 6
    to 9, wherein the monitoring module (107) is adapted to de-
    duce insulation resistance values of the first wires from the
    tapped first signals.

11. Subsea device according to the preceding claim, which is
    adapted to generate a warning signal, if at least one of the
    insulation resistance values decreases below a threshold
    and/or decreases with a rate higher than a threshold rate.

12. Subsea device according to one of the preceding claims 6
    to 11, wherein communicating the first signals (102) is inde-
pendent of/separate from communicating the monitoring signals (109).

13. Subsea device according to one of the preceding claims 6 to 12, further comprising:
   a hose (115) filled with a dielectric fluid (117), in particular constructed to withstand an inside and/or outside pressure between up to 450 bar, further in particular pressure compensatable such that inside pressure substantially equals outside pressure, in which the first wires (101) and in particular the second wires (113) are arranged.

14. Subsea device according to the preceding, further comprising:
   a pressure sensor (121) for measuring a pressure inside the hose (115), wherein the monitoring module (107) is further adapted to receive pressure measuring signals (123) from the pressure sensor (121) and generate the monitoring signals (109) further based on the pressure measurement signals (121).

15. Subsea device according to one of the preceding claims 6 to 14, wherein the monitoring module (107) is adapted to generate a warning signal, if a measured pressure inside the hose decreases below a pressure threshold and/or decreases with a rate higher than a pressure threshold rate.

16. Subsea device according to one of the preceding claims 6 to 15, further comprising:
   second electrical wires (113) for transporting the monitoring signals (109).

17. Subsea device according to the preceding claim, wherein the communication interface comprises:
   a wire-based communication interface (111a) connected to the second electric wires (113).
18. Subsea device according to one of the preceding claims 6 to 17, further comprising:
   a transceiver adapted to wirelessly transport the monitoring signals and in particular receive a monitoring request,
   wherein the communication interface comprises:
   a wireless communication interface (111b) connected to control the transceiver.

19. Subsea device according to one of the preceding claims 6 to 18, further comprising:
   a canister (131) having an enclosure (129) surrounded by a sea water tight wall (131) withstanding high pressure, wherein the wire taps (105), the monitoring module (107) and the communication interface (111a, 111b) are arranged within the enclosure, the canister (131) in particular being arranged close to or at one end of the hose (115).

20. Subsea device according to one of the preceding claims 6 to 19, further comprising:
   a connector (133) for connecting the first electrical wires (101), and in particular also the second electrical wires (113), to other equipment, the connector in particular being wet mateable, the canister in particular being arranged between the connector and the hose.

21. Subsea device according to one of the preceding claims 6 to 20, wherein the communication interface (111a, 111b), in particular complying to Ethernet, further in particular complying to SMNP, is adapted to receive a monitoring request and to transmit a monitoring answer via the monitoring channel,
   wherein the communication interface has a network address, in particular an IP-address.
22. Subsea communication system, comprising:
   a topside station (551) installed above sea level (553);
   a subsea distribution unit (559) installed in the sea
   and communicatively connected to the topside station (551),
   in particular via an optical fiber (555) or metal cable;
   a subsea device (500) according to one of the preceding
   claims connected at one end to the subsea distribution unit
   (559).

23. Subsea communication system according to the preceding
   claim, wherein the subsea distribution unit (559) is config-
   ured to forward the information related to the monitored op-
   erating parameter, in particular the monitoring signals
   (509), received, wire-based or wirelessly, from the communi-
   cation device (500) to the topside station (551).

24. Subsea communication system according to one of the pre-
   ceding claims 22 or 23, further comprising:
   a hub module (565, 565b) adapted to wirelessly receive
   the monitoring signals (509) from the communication device
   (500) and to wire-based transmit the monitoring signals to
   the subsea distribution unit.

25. Subsea communication system according to one of the pre-
   ceding claims 22 to 24, further comprising:
   a subsea electrical module (567);
   wherein the communication device is connected at the other
   end to the subsea electrical module (567).

26. Subsea communication system according to the preceding
   claim, further comprising:
   an operation device (561) for a subsea exploration;
   another subsea device (500) according to one of the pre-
   ceding claims 1 to 21 connected between the operation device
   and the subsea electrical module.
27. Subsea communication system according to the preceding claim, wherein the other subsea device (500) communicates operation signals (102) of the operation device (561) as the first signals (102) wire-based to the subsea electrical module (567), wherein the other subsea device (500) wirelessly or wire-based communicates its monitoring signals (509) to the communication device (500).

28. Subsea communication system according to one of the preceding claims 25 or 26, wherein the operation device is a sensor device (562) for measuring a physical property, in particular pressure or flow rate of gas and/or oil explored and/or conveyed in a subsea operation, wherein the operation signals (102) comprise sensor signals of the sensor device.

29. Subsea communication system according to the preceding claim, further comprising:

another hub module (565b) configured to receive the wirelessly transmitted monitoring signals of the other subsea device (500) and to transfer the monitoring signals (509) via the subsea device (500) and the subsea distribution unit (559) to the topside station (551).

30. Subsea communication system according to one of the preceding claims, further comprising:

an optical fiber (555) connected to the topside station; an optical/electrical converter (557) connected to the subsea distribution unit (559) and to the optical fiber (555) and adapted to convert electrical communication signals to optical communication signals and vice versa.

31. Method for monitoring a subsea device, in particular a subsea cable, the method comprising:

monitoring an operating parameter of the subsea device, and
transmitting information related to the monitored operating parameter.

32. Method according to the preceding claim, further comprising:

- communicating, using first electrical wires (101) of the subsea device, first signals (102);
- tapping, at the subsea device, the first wires (101);
- deducing, at the subsea device, a state of the first wires;
- generating, at the subsea device, monitoring signals (109) at least based on the state of the first wires, the monitoring signals representing the information related to the monitored operating parameter;
- controlling, at the subsea device, communicating the monitoring signals (109).

33. Method for monitoring a subsea device (100, 500) during a subsea application, the method comprising:

- communicating, using first electrical wires (101) of the subsea device, first signals (102);
- tapping, at the subsea device, the first wires (101);
- deducing, at the subsea device, a state of the first wires;
- generating, at the subsea device, monitoring signals (109) at least based on the state of the first wires;
- controlling, at the subsea device, communicating the monitoring signals (109).
## FIG 4

<table>
<thead>
<tr>
<th>Pin number</th>
<th>Signal</th>
<th>Pin number</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24VDC</td>
<td>7</td>
<td>Eth1 SEM TX+</td>
</tr>
<tr>
<td>2</td>
<td>0VDC</td>
<td>8</td>
<td>Eth1 SEM TX-</td>
</tr>
<tr>
<td>3</td>
<td>Optional 24VDC</td>
<td>9</td>
<td>Eth2 SEM RX+</td>
</tr>
<tr>
<td>4</td>
<td>Optional 0VDC</td>
<td>10</td>
<td>Eth2 SEM RX-</td>
</tr>
<tr>
<td>5</td>
<td>Eth2 SEM TX+</td>
<td>11</td>
<td>Eth1 SEM RX+</td>
</tr>
<tr>
<td>6</td>
<td>Eth2 SEM TX-</td>
<td>12</td>
<td>Eth1 SEM RX-</td>
</tr>
<tr>
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# INTERNATIONAL SEARCH REPORT

## A. CLASSIFICATION OF SUBJECT MATTER

**INV. H04B3/00  H04B3/46**

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)

H04B

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

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>EP 2 339 359 A2 (VIPER SUBSEA LTD [GB])</td>
<td>1,2, 4-13,17, 22,23, 25-27, 29,31,33</td>
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<td>29 June 2011 (2011-06-29)</td>
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<td>WO 2012/041535 A1 (SIEMENS AG [DE]; BREKKE ENDRE [NO]; HORTEN VEGARD [NO])</td>
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**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 application or patent but published on or after the international filing date

**L** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

**O** document referring to an oral disclosure, use, exhibition or other means

**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

**Y** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

**S** document member of the same patent family

Date of the actual completion of the international search: 26 September 2016

Date of mailing of the international search report: 04/10/2016

Name and mailing address of the ISA/ European Patent Office, P.B. 5018 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-3040, Fax: (+31-70) 340-3016

Authorized officer: De Iulis, M

Form PCT/ISA/210 (second sheet) (April 2005)
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<td>EP 2339359</td>
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