Title: SUBSEA CONTROL MODULE SYSTEM

Abstract: A subsea control module system (10) comprising control modules (20, 30) for controlling a subsea device (2). One of the modules (20, 30) is an electric power control module (20) comprising a connection interface (22) with stab mate connectors (22a) and further comprising a communication unit (25) for communication with other control modules (20, 30) and with the subsea device (2), and an electric power control unit (26) for controlling electric power supplied to the subsea device (2) via the connection interface (22). One of the modules (20, 30) is a hydraulic power control module (30) that comprises a communication unit (35) for communication with other control modules (20, 30) and a hydraulic power control unit (36) for controlling hydraulic power supplied to the subsea device (2) via the connection interface (32). The control modules (20, 30) are independently disconnectable from and connectable to the subsea device (2).

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SUBSEA CONTROL MODULE SYSTEM

FIELD OF THE INVENTION

The present invention relates to a subsea control module system and a Christmas tree with such a subsea control module system.

BACKGROUND OF THE INVENTION

Different types of subsea devices are used in subsea oil/gas installations. In fig. 1, a part of a subsea oil/gas installation 1 is shown, with one typical subsea device 2 is the Christmas tree connected to a well-head (not shown) of an oil/gas well. In fig. 1, it is shown that the Christmas tree is connected to an umbilical termination assembly (UTA) via a communication jumper 5a, electrical jumper 5b, and hydraulic/chemical jumper 5c. An umbilical 3 is connected between the UTA and a topside installation (not shown).

A subsea control module (SCM) is connected to a connection interface 2a (fig. 2) of the Christmas tree 2. The SCM shown in fig. 2 and 3 has been manufactured and sold by FMC Subsea Technologies for many years. The SCM contains electronics, instrumentation, and hydraulics for safe and efficient operation of subsea tree valves, chokes, and also downhole valves in the well. The SCM also reads external sensors mounted on the subsea tree and can control electrical actuators.

The subsea control module (SCM) is large (height approx. 1.80-2.0 m, weight approx 1700-2000 kg). Due to its size, it also contributes to the size of the subsea device itself, as the subsea device must have relatively large compartment/funnel for the SCM and also a supporting structure for carrying the weight of the SCM.

Today, the owner and/or operator and/or legislator of the respective oil/gas field have different requirements for the subsea devices and its SCMs. The project specific hydraulic schematics are put straight into the hydraulic manifold within the SCM, driving variances, i.e. which is increasing the number of variants of the SCM. The SEM (subsea electronics modules) internal in the SCM, is variance driven by primarily external sensors and distribution options. Since all these factors are incorporated in the same physical module, it will not be possible to standardize products across operators. Accordingly, almost all SCMs are tailor-made for its specific subsea device, which contributes to manufacturing costs and a substantial delivery time.

Moreover, the SCM is too heavy to be lifted into or out from the connection interface of its subsea device by means of a ROV. Hence, an installation or retrieval of the SCM requires a cumbersome operation, since a wireline enabled vessel is needed and the SCM must be handled onboard the vessel.
The oil and gas industry is facing several challenges with respect to reducing costs for subsea equipment and subsea operations. Hence, one object is to reduce the size and cost of control devices for subsea devices and their control modules and to make the installation and retrieval process easier and quicker. One specific object is to provide a control system where the modules are ROV operable.

Another object of the invention is to, allowing for stricter standardization of such control modules across operators, while at the same time allowing the owner and/or operator of the oil/gas field to adapt the control devices according to their specifications and configuration of the field.

The third objective is to provide a system with shorter production time, by offering standard modules with standard interfaces, such that the products can be automatically configured, tendered, planned and tested, resulting in lead time reductions, engineering and production hours reduction and ultimately project and system savings.

A prior art well Christmas tree is illustrated schematically in fig. 8. The well head comprises a flow control module and the above mentioned SCM connected to different types of instrumentation, such as multiphase meters, choke valve etc. The purpose of the choke valve is to control the fluid rate and/or fluid pressure out from the Christmas tree, as the fluid rate and/or fluid pressure out from the well below the Christmas tree will be varying.

The purpose of the multiphase meter is to measure the constituent phases of the well fluid from the well.

A Christmas tree has an expected life of operation of about 20 years. However, some parts, such as multiphase meters, choke valves etc. has a shorter expected life of operation. It is often also desired to add new functionality to a Christmas tree, due to new or improved technology, such as increased accuracy, increased safety, etc. Hence, the SCM and/or the flow control module must be replaced more often than every 20 years.

With the prior art Christmas tree, if the SCM and/or the flow control module must be replaced, this will in many situations require both the SCM and the flow control to be replaced, as new functionality in the flow control module requires new functionality within the SCM and vice versa. A wireline operation is need for both the SCM and the flow control module.

One object of the present invention is to reduce the number of operation needed when replacing a flow control module.
SUMMARY OF THE INVENTION

The present invention relates to a subsea control module system comprising control modules for controlling a subsea device, where:
- at least one of the modules is an electric power control module comprising a connection interface with stab mate connectors for connection to the subsea device at one side of the module;
- the electric power control module comprises a communication unit for communication with other control modules and an electric power control unit for controlling electric power supplied to the subsea device via the connection interface;
- at least one of the modules is a hydraulic power control module comprising a connection interface with stab mate connectors for connection to the subsea device;
- the hydraulic power control module comprises a communication unit for communication with other control modules and a hydraulic power control unit for controlling hydraulic power supplied to the subsea device via the connection interface;
- the control modules are independently disconnectable from and connectable to the subsea device.

According to the above, the functions related to the supply of electric power is separated from the function of supplying hydraulic power. Hence, a reduction of the size of each of these modules is achieved. Each of these modules in this subsea control module system is ROV operable, i.e. each module may be lowered onto and lifted up from a connection interface of the subsea device. Moreover, the ROV can be used to connect the modules to each other by means of jumpers. Accordingly, no wireline enabled vessel is necessary.

The subsea control module system receives electric energy from topside via the umbilical, umbilical termination assembly and electric jumper. Alternatively, the subsea control module system receives electric energy from a subsea electric power source, such as a battery bank or from other electric power control modules of the installation. The subsea control module system receives hydraulic energy from topside via the umbilical, umbilical termination assembly and hydraulic jumper. Alternatively, the subsea control module system receives hydraulic energy from a subsea hydraulic power source, such as an accumulator or from other hydraulic power control modules of the installation. The subsea control module system is provided in communication with the subsea device and topside, again via the umbilical, umbilical termination assembly and a communication jumper. Alternatively, the communication with topside is provided via other control modules.
It should be noted that the electric, hydraulic and/or communication jumpers can be connected directly between the umbilical termination assembly and the respective electric/hydraulic power control modules. Alternatively, the jumpers can be connected to the electric/hydraulic power control modules via the connection interface of the subsea device. In the same way, the electric power control module can be connected to the hydraulic power control module either directly by means of jumpers or via the connection interface of the subsea device.

Moreover, it should be noted that there is a digital interface between the electric power control module and the hydraulic power control module. In this way, the electrical power control module electrically relates to the hydraulic control module as if it was an instrument and/or sensor.

Moreover, it should be noted that more than one function may be integrated into one jumper, i.e. communication and hydraulic fluid lines may typically be integrated into one jumper, or communication and electric power lines may typically be integrated into one jumper.

In addition, functionality is separated into different modules. Hydraulic control functionality is provided by the hydraulic power control module while electric control functionality is provided by the electric power control module.

The subsea control module system supplies electric power to electric equipment of the subsea device, the electric equipment being electric actuators (choke valves, motors etc) and other electronic circuits (such as sensors). The electric power may be AC power, DC power or both DC and AC power.

The subsea control module system supplies hydraulic power to hydraulic equipment of the subsea device, the hydraulic equipment being hydraulically controlled valves etc. More than one type of hydraulic power can be supplied, such as both high pressure hydraulic fluid and low pressure hydraulic fluid.

The subsea control module system also provides communication with the subsea device. In one aspect, the communication unit of the electric power control module is providing communication with the subsea device, in another aspect the communication unit of the hydraulic power control module is providing communication with the subsea device, and in yet another aspect, both communication units are providing communication with electric equipment provided on the subsea device.

In one aspect, the electric power control unit of the power control module is configured to control electric power supplied to the hydraulic power control unit of the hydraulic power control module. Hence, an electric power control module may be used separately when no hydraulic control is necessary, while the hydraulic
power control module is dependent on electric energy supplied from an electric power control module.

In one aspect, the stab mate connectors are connectable to connection interfaces of the subsea device and where the electric power control module comprises a jumper connection interface accessible for connection to or connection from a jumper when the stab mate connectors are connected to the subsea device by means of their stab mate connectors.

In one aspect, the electric power control module and the hydraulic power control module are connectable to an umbilical termination assembly via jumpers.

In one aspect, the system comprises an electric jumper having a first end for connection to the electric power control module and a second end for connection to the umbilical termination assembly, where the electric jumper comprises a transformer device incorporated into the electric jumper. In prior art, this transformer device is located within the SCM. By moving the transformer device into the jumper, a reduction of the size and weight of the electric power control module can be achieved. In addition, it is easier to achieve a standardized distribution voltage.

In one aspect, the hydraulic power control unit is configured to be supplied with hydraulic fluid directly from a hydraulic jumper connected to the umbilical termination assembly or directly from a subsea hydraulic accumulator.

One example of such a subsea device is a Christmas tree. The present invention also relates to a Christmas tree comprising:
- a flow control module with a choke valve;
- a subsea control module system as described above, where:
- the flow control module is retrievable from the Christmas tree;
- the hydraulic power control module is releasably connected to the Christmas tree adjacent to, or at a distance from, the flow control module;
- the electric power control module is releasably connected to the flow control module of the Christmas tree;
- the choke valve is controlled by the electric power control module.

Accordingly, when retrieving the flow control module from the Christmas tree, the electric power control module is retrieved together with the flow control module while the hydraulic power control module is still being connected to the Christmas tree. In addition to the choke valve, also the multiphase meter and other equipment with relatively shorter expected life of operation is retrieved in one run. This equipment (including the electric power control module) is also most likely to have an upgrade, and hence, the entire flow control module may be replaced with an upgraded flow control module. Another consequence is that the standardization of
the Christmas tree becomes easier, as most of the more complex and project-specific components are moved from the Christmas tree itself to the flow control module of the Christmas tree. Accordingly, only more generic functionality will be located on the Christmas tree itself.

Of course, the electric power control module may be disconnected from the flow control module and retrieved to surface alone. Also the hydraulic power control module may be disconnected from the Christmas tree and retrieved to surface alone.

In one aspect, a vibration sensor, sand/erosion sensor, chemical injection valves (CIV), hydrocarbon leak detectors and downhole interface modules are connected to the flow control module. The vibration sensor, sand/erosion sensor, chemical injection valves (CIV), hydrocarbon leak detectors and downhole interface modules have previously been located on the Christmas tree itself.

In one aspect, one or more split boxes may be connected between the electric power control module and the choke valve of the flow control module. In this way, the number of stab connectors of the electric power control module may be reduced.

According to the above, separation of the control modules into a electric power control module and a hydraulic power control module makes it possible to place the hydraulic power control module near hydraulic supply or hydraulic actuators, while the electric power control module can be placed at a central location close to most instrumentation and/or connection points. The placement of these separate modules can also be used to balance weight and COG (Centre of Gravity) of the subsea device and optimization of weight.

Moreover, it achieved that electric power and communication architecture can be be identical both for electrohydraulic systems and for all electric systems. As the need for electric power is higher for electrohydraulic systems, the use of an additional battery bank still makes it possible to use the same electrical power control module, although intermediate electric energy need increases. The intermediate energy would be supplied by the battery bank and trickle charged back by regular power input via jumper from the system.

DETAILED DESCRIPTION

Embodiments of the invention will now be described with reference to the enclosed drawings, where:

Fig. 1 illustrates a part of a prior art subsea oil/gas installation;
Fig. 2 illustrates a perspective view of the prior art subsea control module and its connection interface on the subsea device;
Fig. 3 illustrates a side view of the prior art subsea control module;
Fig. 4 illustrates a perspective view of the subsea hydraulic power control module;
Fig. 5 illustrates a perspective view of the subsea electric power control module; Fig. 6 illustrates an electrical jumper with integrated transformer; Fig. 7 illustrates schematically the hydraulic power control module and the electric power control module; Fig. 8 illustrates a prior art Christmas tree with SCM schematically; Fig. 9 illustrates an embodiment of a Christmas tree schematically; Fig. 10 illustrates an alternative embodiment of fig. 9; Fig. 11 illustrates an alternative embodiment to fig. 7.

A subsea control module system according to the invention will now be described. As an introductory remark, a hydraulic power control module 30 of this module system is shown in fig. 4 and an electric power control module 20 of this module system is shown in fig. 5, where the size of the modules 20, 30 is comparable in size with the prior art SCM of fig. 3.

The subsea control module system is generally referred to with reference number 10 in the drawings. It is now referred to fig. 7, showing a subsea oil/gas installation 1 and a topside installation 7. The subsea installation 1 typically comprises several subsea devices, where only one subsea device 2 is indicated as a rectangular box in fig. 7. The subsea device 2 may be a Christmas tree, a manifold, a separator, a pump, a compressor, an Electrical Distribution Unit (EDU), a Power Distribution Unit (PDU), a PipeLine End Manifold (PLEM), and a Pipeline End Termination (PLET).

The subsea device 2 is shown with two connection interfaces 2a, 2b.

The subsea control module system 10 is used to actuate electric driven and hydraulic driven actuators of the subsea device 2 (such as control valves, chokes chemical injection valves, barrier valves etc.) or in equipment below the subsea device 2 (such as downhole safety valves (DHSV) or other valves in the well head or well itself). The subsea control module system 10 also receives sensor data from sensors in the subsea device 2 or in in equipment below the subsea device 2.

In the embodiment of fig. 7, the subsea device 2 is controlled electrically and hydraulically. Therefore, the subsea control module system 10 comprises both an electric power control module 20 and a hydraulic power control module 30 connected to the subsea device 2, where the electric power control module 20 is connected to the first connection interface 2a and the hydraulic power control module 30 is connected to the second connection interface 2b. It should be noted that some subsea devices 2 may require more than two such modules 20, 30.
The electric power control module 20 comprises a housing 21 and a connection interface 22 with stab mate connectors 22a for connection to the first connection interface 2a of the subsea device 2. The connection interface 22 is located at one side of the housing 21, preferably underneath the housing 21. Inside the electric power control module 20 a communication unit 25 and an electric power control unit 26 are shown. These units 25, 26 are drawn within a dashed box SEM (subsea electronic module). The SEM is provided within a pressure-sealed compartment.

The communication unit 25 is provided for communication with the hydraulic power control module 30. If other control modules 20, 30 are connected to the subsea device 2, the communication unit 25 may also be provided in communication with such control modules 20, 30. In addition, the communication unit 25 is provided for communication with the subsea device 2 and with a topside communication unit 7a of the topside installation 7. The communication unit 25 typically receives sensor data from sensors provided in the subsea device 2 or in equipment below the subsea device 2 (sensors in the well head, in the well etc.)

The electric power control unit 26 is controlling the electric power supply to the subsea device 2 via the connection interface 22, for example by turning the electric power supply to one of, or a number of, the connectors 22a of the connection interface 22 on or off. Alternatively, the electric power supply is controlled by changing the voltage and/or current amplitude or by changing the frequency of an alternating voltage and/or current.

The hydraulic power control module 30 comprises a a housing 31 and a connection interface 32 with stab mate connectors 32a for connection to the second connection interface 2b of the subsea device 2. The connection interface 32 is located at one side of the housing 31, preferably underneath the housing 31. Inside the hydraulic power control module 30 a communication unit 35 and hydraulic power control unit 36 are shown. The unit 35 are drawn within a dashed box SEM (subsea electronic module). The SEM is provided within a pressure-sealed compartment.

The hydraulic power control unit 36 receives low pressure and/or high pressure hydraulic fluids via the connectors 32 and is performing control of the output of these fluids to the subsea device 2 by opening and closing valves within the unit 36. Also return fluid from the subsea device 2 is received by the module 30 via the unit 36. Some parts of the subsea device 2 (for example valves in a Christmas tree) require a low pressure hydraulic fluid to be operated, while other parts of the subsea device 2 (for example the downhole safety valve (DHSV) below the subsea device 2) require a high pressure hydraulic fluid to be operated.

In the present embodiment, these valves are electrically controlled by means of electric motors supplied with electric energy from the electric power control module 20. Hence, the electric power control unit 26 of the power control module 20 is
configured to control electric power supplied to the hydraulic power control unit 36 of the hydraulic power control module 30.

In addition, the hydraulic power control unit 36 comprises internal sensors (not shown) necessary to monitor and provide feedback in order to control such a unit.

Hence, also the hydraulic power control unit 36 comprises electronic circuitry.

The communication unit 35 is provided for communication with the electric power control module 20. If other control modules 20, 30 are connected to the subsea device 2, the communication unit 35 may also be provided in communication with such control modules 20, 30. In the present embodiment, the communication unit 35 is communicating with the subsea device 2 and with the topside communication unit 7a of the topside installation 7 via the electric power control module 20. Alternatively, the communication unit 35 is communicating directly with the subsea device 2 via the connection interface 2b and with the topside communication unit 7a of the topside installation 7 via a communication jumper, the umbilical termination assembly and the umbilical. This alternative embodiment is indicated with the dot-dashed box denoted "sensors" connected to the module 30 of fig. 7.

It should be noted that the control modules 20, 30 are independently disconnectable from and connectable to the subsea device 2.

Moreover, it should be noted that in the present embodiment, there is a digital interface between the electric power control module and the hydraulic power control module. This can be a standard interface for electric power and communication. In this way, the electrical power control module 20 electrically relates to the hydraulic power control module 30 as if it was an instrument and/or sensor.

In fig. 7, it is shown that each control module 20, 30 comprises a ROV lifting handle 27, 37 used by a ROV to lower the control modules 20, 30 onto the connection interface 2a, 2b respectively, and for lifting the control modules 20, 30 up from the connection interface 2a, 2b respectively. Hence, the connection interface 22, 32 may be connected to a connection interface of the subsea device 2 by lowering the module 20 onto the connection interface 2a, 2b and the connection interface 22, 32 may be disconnected from the connection interface 2a, 2b of the subsea device 2 by elevating the module 20 away from the connection interface of the subsea device 2. The ROV-handles may also be used for example to lock the modules to the subsea device 2.

The electric power control module 20 further comprises a jumper connection interface 28. The jumper connection interface 28 is accessible for connection to or connection from a jumper by means of a ROV when the stab mate connectors 22a are connected to the connection interface 2a of the subsea device 2. Preferably the
jumper connection interface 28 is located on top of the housing 21 or on an upper area of one of the side surfaces of the housing 21.

In fig. 7, it is shown that the control module 20 comprises two such jumper connection interfaces 28a, 28b. The first jumper connection interface 28a is connected to the umbilical termination assembly by means of an electric jumper 40 shown in fig. 6. This electric jumper 40 comprises a first end 42 for connection to the electric power control module 20 and a second end 43 for connection to the umbilical termination assembly UTA. A transformer device 45 is incorporated into the electric jumper 40, for transforming a voltage level outputted from the umbilical termination assembly UTA to a different voltage level inputted to the control module 20. It should be noted that a prior art electric jumper 5b (shown in fig. 1) may also be used for connecting the control module 20 to the umbilical termination assembly UTA.

The second jumper connection interface 28b is connected to the umbilical termination assembly UTA by means of a communication jumper 5a.

In fig. 7, it is shown that the control module 30 is connected to the umbilical termination assembly UTA by means of a hydraulic jumper 5c.

It should be noted that in fig. 7, the communication jumper 5a and the electric jumper 40 are connected directly to the electric power control module 20 while the hydraulic jumper 5c is connected to the hydraulic power control module 30 via the connection interface 2b of the subsea device 2. It should be noted that also the jumpers 5a and 40 could be connected to the power control module 20 via the connection interface 2a of the subsea device 2.

Moreover, in an example where two electric power control modules 20 are connected to a subsea device 2, these two electric power control modules 20 could be connected to each other via connection interfaces 2a of the subsea device 20 or via the jumper connection interfaces.

It should be noted that some of these jumpers could be combined into one single jumper, for example electrical power lines and communication lines integrated into one single jumper. Moreover, the connectors 28a, b, and/or 22a could also have combined functionality, i.e. one connector could have both communication pins and electric power pins. In addition, there could be more than one of the above jumpers in parallel for the purpose of redundancy.

It is now referred to fig. 9. Here, a subsea device 2 in the form of a Christmas tree is shown as a box denoted XT. The Christmas tree XT comprises a flow control module 6 with a choke valve 6a and a multiphase meter 6b. As is known from prior art, the flow control module 6 is retrievable from the Christmas tree XT. The
Christmas tree comprises a subsea control module system 10 as described above. The electric power control module 20 is releasably connected to the flow control module 6 of the Christmas tree XT, while the hydraulic power control module 30 is releasably connected to the Christmas tree XT adjacent to, or at a distance from, the flow control module 6. Hence, when retrieving the flow control module 6 from the Christmas tree, the electric control module 30 is retrieved together with the flow control module 30, while the hydraulic power control module 30 is still connected to the Christmas tree.

In fig. 9, lines are drawn between the boxes representing the electric power control module 20, the hydraulic power control module 30, the topside installation 7 and three groups of instrumentation:
- instrumentation fixed to the Christmas tree (i.e. not to the flow control module). This type of instrumentation is the pressure and temperature sensors up/down stream of the barrier valves of the Christmas tree.
- instrumentation on the flow control module, such as the choke valve 6a, the multiphase meter 6b.
- instrumentation previously fixed to the Christmas tree, which in the present invention is connected to the flow control module. This can be a vibration sensor, sand/erosion sensor, chemical injection valves (CIV), hydrocarbon leak detectors and downhole interface modules.

The lines between the boxes are communication lines and electric power supply lines. Hence, hydraulic power supply lines are removed from fig. 9. All these three groups of instrumentation are connected to the electric power control module 20.

Hence, all or most of the instrumentation having an expected life of operation less than the expected life of operation for the Christmas tree are in fig. 8 located on the flow control module 6. The same instrumentation is also the type of instrumentation that are likely to be upgraded to get new functionality, improved sensing capabilities etc.

The choke valve 6a of the flow control module 6 is controlled by the electric power control module 20. The multiphase meter 6b is connected to the electric power control module 20 and the control module 20 receives sensor data from the meter 6b.

It is now referred to fig. 10. Here, split boxes SB are connected between the electric power control module 20 and the choke valve 6a. Correspondingly, split boxes are connected between the other instrumentation and the electric power control module 20. The connection between the modules 20, 30 is also provided through a split box. The purpose of the split boxes SB is to reduce the number of connectors (stab connectors and ROV connectors) of the electric power control module 20. Hence, these split boxes also contributes to a reduced size of the electric power control module 20.
Alternative embodiment

It is now referred to fig. 11. Here, electric power could be supplied to the electric power control module 20 by means of a subsea electric source, such as a battery bank 8. The battery bank 8 here supplies electric power in addition to electric power supplied from topside. Hydraulic power is supplied to the hydraulic power control module 30 by means of a subsea hydraulic accumulator 9. The battery bank is connected to the control module 20 via connection interface 2a, while the accumulator 9 is connected to the control module 30 via connection interface 2b.

In the description above, communication is performed by means of CAN bus communication, power line communication, Ethernet, and/or other communication methods known for a skilled person.

Moreover, the control of supply of electric power and hydraulic power may be performed based on control signals sent from the topside installation 7. This can be manual control signals sent by an operator, or control signals computed by a topside control system based on signals from sensors in the subsea installation 1, for example in the subsea device 2 or sensors provided within the modules 20, 30. In addition, control of supply of electric power and hydraulic power may be performed based on control signals sent from the communication units 26, 36 of the control modules 20, 30 to the control units 25, 35 based on signals from sensors in the subsea device 2 or control modules 20, 30.

By separating the control system into the hydraulic power control module 30 and the electric power control module 20, the size of the modules has been decreased. The weight of each of the modules 30, 20 of fig. 4 and 5 are so low that they can be disconnected from and connected to the subsea device 2 by means of a ROV. Accordingly, the cost and time involved for installing and retrieving such modules 20, 30 are considerably reduced.

In addition, the modules 20, 30 may comprise wireless communication units (not shown. These wireless communication units can be considered optional and can be used as back-up or communication in operation phases of life of field, typical installation, commissioning or ROV intervention.
CLAIMS

1. Subsea control module system (10) comprising control modules (20, 30) for controlling a subsea device (2), where:

- one of the control modules (20, 30) is an electric power control module (20) comprising a connection interface (22) with stab mate connectors (22a) for connection to the subsea device (2) at one side of the module (20);

- the electric power control module (20) comprises a communication unit (25) for communication with other control modules (20, 30) and with the subsea device (2), and an electric power control unit (26) for controlling electric power supplied to the subsea device (2) via the connection interface (22);

- one of the control modules (20, 30) is a hydraulic power control module (30) comprising a connection interface (32) with stab mate connectors (32a) for connection to the subsea device (2);

- the hydraulic power control module (30) comprises a communication unit (35) for communication with other control modules (20, 30) and a hydraulic power control unit (36) for controlling hydraulic power supplied to the subsea device (2) via the connection interface (32);

- the control modules (20, 30) are independently disconnectable from and connectable to the subsea device (2).

2. Subsea control module system (10) according to claim 1, where the electric power control unit (26) of the electric power control module (20) is configured to control electric power supplied to the hydraulic power control unit (36) of the hydraulic power control module (30).

3. Subsea control module system (10) according to claim 1 or 2, where the stab mate connectors (22a, 32a) are connectable to connection interfaces (2a, 2b) of the subsea device (2) and where the electric power control module (20) comprises a jumper connection interface (28) accessible for connection to or connection from a jumper when the stab mate connectors (22a) of the electric power control module (20) are connected to the connection interface (2a) of the subsea device (2).

4. Subsea control module system (10) according to any one of the above claims, where the electric power control module (20) and the hydraulic power control module (30) are connectable to an umbilical termination assembly (UTA) via jumpers.

5. Subsea control module system (10) according to claim 4, where the system (10) comprises an electric jumper (40) having a first end (42) for connection to the electric power control module (20) and a second end (43) for connection to the
umbilical termination assembly (UTA), where the electric jumper (40) comprises a transformer device (45) incorporated into the electric jumper (40).

6. Subsea control module system (10) according to claim 4 or 5, where the hydraulic power control unit (36) is configured to be supplied with hydraulic fluid directly from a hydraulic jumper (5c) connected to the umbilical termination assembly (UTA) or directly from a subsea hydraulic accumulator (9).

7. Christmas tree (XT) comprising:
   - a flow control module (6) with a choke valve (6a);
   - a subsea control module system (10) according to claim 1; where:
     - the flow control module (6) is retrievable from the Christmas tree (XT);
     - the hydraulic power control module (30) is releasably connected to the Christmas tree (XT) adjacent to, or at a distance from, the flow control module (6);
     - the electric power control module (30) is releasably connected to the flow control module (6) of the Christmas tree (XT);
     - the choke valve (6a) is controlled by the electric power control module (30).

8. Christmas tree (XT) according to claim 7, where a vibration sensor, sand/erosion sensor, chemical injection valves, hydrocarbon leak detectors and downhole interface modules are connected to the flow control module (6).

9. Christmas tree (XT) according to claim 7 or 8, where a split box (SB) is connected between the electric power control module (30) and the choke valve (6a).
### A. CLASSIFICATION OF SUBJECT MATTER

**INV. E21B33/035**

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)

**E21B**

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>
<thead>
<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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<tbody>
<tr>
<td><strong>X</strong></td>
<td>GB 2 318 815 A (BRISCO ENG LTD [GB]) 6 May 1998 (1998-05-06) page 2, line 8 - page 3, line 11 page 6, line 6 - page 9, line 31; figures 3, 4a, 4b, 6-8</td>
<td>1-4, 6</td>
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<td><strong>Y</strong></td>
<td>EP 2 571 034 A1 (SIEMENS AG [DE]) 20 March 2013 (2013-03-20) paragraphs [0002], [0044]; figure 1</td>
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<tr>
<td><strong>Y</strong></td>
<td>EP 2 383 428 A2 (HYDRIL USA MFG LLC [US]) 2 November 2011 (2011-11-02) paragraphs [0039], [0042] - [0048]; figures 5-9</td>
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**Category**
- **X**: From general to specific.
- **Y**: From specific to general.

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