(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 July 2015 (16.07.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/105839 A1

(51) International Patent Classification:
H04B 13/02 (2006.01)

(21) International Application Number:
PCT/US2015/010430

(22) International Filing Date:
7 January 2015 (07.01.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/924,546 7 January 2014 (07.01.2014) US
14/591,231 7 January 2015 (07.01.2015) US

(71) Applicant: **OCEANEERING INTERNATIONAL, INC.** [US/US]; 11911 Fm529, Houston, Texas 77041 (US).

(72) Inventors: **KERINS, Kevin Franes**; 30 Southgate Drive, The Woodlands, Texas 77380 (US). **PHILIP, Mark Charles**; 17715 Fairhaven Lake Dr., Cypress, Texas 77433 (US).

(74) Agent: **MAZE, Gary Robin**; 211 E Parkwood Ave, Suite 110, Friendswood, Texas 77546 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: DATA TRANSMISSION AND CONTROL OVER POWER CONDUCTORS

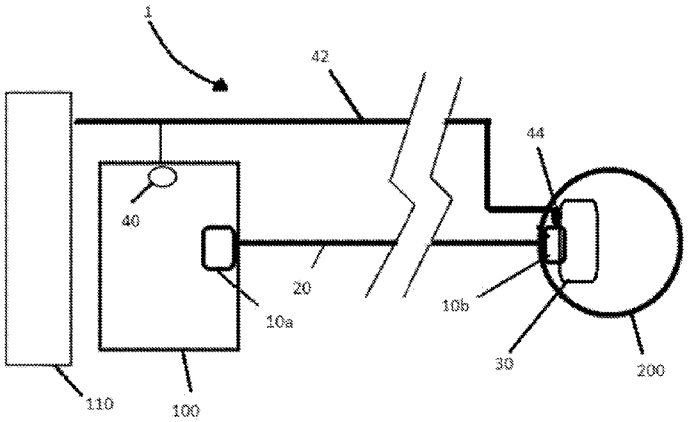

FIGURE 1

(57) Abstract: A system for controlling a subsea device comprises a complimentary set of data communication interfaces operatively coupled to an electronically interrogatable component of a subsea device and a remotely disposed device controller via a power conductor which defined data pathway between the subsea device and the remotely disposed device controller. A data transceiver is operatively coupled to the electronically interrogatable component and the remotely disposed device controller via the complimentary set of data communication interfaces over the power conductor. In configurations, control and/or telemetry or other data may be unidirectionally and/or bidirectionally transmitted between the electronically interrogatable component of a subsea device and a remotely disposed device controller. In configurations, data faults may be monitored in a primary data path and, if a fault detected, control and/or telemetry or other data transmission switched to the power conductor data pathway, manually and/or automatically.

WO 2015/105839 A1

DATA TRANSMISSION AND CONTROL OVER POWER CONDUCTORS

RELATION TO OTHER APPLICATIONS

[0001] This application claims priority through United States Provisional Application 61/924,546 filed January 7, 2014.

BACKGROUND

[0002] At times, having a data pathway between a subsea device such as a remotely operated vehicle (ROV) or other subsea device which minimizes data pathway runs is desirable. The data pathway can be used for control data, e.g. commands, and telemetry such as video telemetry. Although extra fibers or other pathways may be inexpensive and easy to use for such a data pathway, extra fibers may not always provide real redundancy. Moreover, many ROV and other subsea systems do not have fiber capability.

[0003] Further, at times a primary means of communication may fail, e.g. such as after suffering fiber failures in the umbilical and/or tether, and a readily available backup data transmission system is advantageous. Failures can include cyclical redundancy check (CRC) failures, total failures (e.g. fiber paths break or become otherwise unusable), or the like, or a combination thereof.

FIGURES

[0004] Various figures are included herein which illustrate aspects of embodiments of the disclosed inventions.

[0005] **Fig. 1** is a block diagram of an exemplary embodiment of the invention.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0006] This invention includes a means by which a remotely operated vehicle (ROV) or other subsea device may be controlled using control and video telemetry transmitted over the power conductors in an umbilical and/or tether attached to the ROV or device rather than using primary data pathways such as fiber optics. Such transmission can be used as a potential backup for current systems such as via ROV umbilicals should the primary communication system fail such as after suffering fiber failures in the umbilical and/or tether, as a backup system or even as a primary data transmission system. The invention uses umbilical or other power conductors coupled to interfaces such as power line modems to effect uni- and/or bi-directional data transmission.

[0007] Although this can be a primary data communications system, the control system can also be used to switch from fiber mode to power line transmission mode such as when a fiber failure is detected, either automatically or manually or both. Alternatively, control can be manually switched between a primary system such as a fiber optics based system to using umbilical power conductors a data transmission system. If a subsea system such as an ROV has a plurality of power lines, a plurality of power line modems may be employed to provide redundancy or additional redundancy. The ability to use power lines for communications may also be used to supply a redundant, backup, and/or primary data system for other products such as a subsea field pumping system and others that rely on power conductors and fibers for power and control.

[0008] Accordingly, existing power conductors according to the invention allow for transmission of control and/or telemetry data without requiring extra fibers. Although the technology may not provide the bandwidth that fiber data transmission can bring, it can provide

sufficient bandwidth, either baseband or broadband, for control and video. Thus, both or either of these uses (data or video) may be of a lower bandwidth than primary systems such as fiber based modes, but still sufficient to effect the necessary telemetry and control.

[0009] Referring now to **Fig. 1**, system for controlling a subsea device 1 comprises a complimentary set of data communication interfaces 10a and 10b, operatively coupled to and providing pathways between one or more power and/or electronically interrogatable components 110 of subsea device 100 and remotely disposed device controller 200; power conductor 20, operatively coupled to subsea device 100 and remotely disposed device controller 200 via the complimentary set of data communication interfaces 10a,10b, where power conductor 20 defines a power conductor data pathway between the complimentary set of data communication interfaces 10a,10b; and data transceiver 30 operatively coupled to subsea device 100 and remotely disposed device controller 200 via the complimentary set of data communication interfaces 10a and 10b over power conductor 20.

[0010] System 1 may further comprise one or more data transmission failure sensors 40 configured to detect a data transmission failure in one or more associated primary data communications pathways 42. Data transmission switch 44 may be present and operatively in communication with one or more data transmission failure sensors 40 and data transceiver 30, where data transmission switch 44 is configured to detect a data transmission failure one or more of the primary data communications pathways 42 and, upon such a detection, cause data transceiver 30 to transmit data over a power conductor data pathway defined by one or more predetermined power conductors 20.

[0011] Power conductor 20 is typically configured to provide power as well as data to subsea device 100 and, in embodiments, may comprise one or more power conductors disposed in an umbilical or tether attached to subsea device 200.

[0012] In embodiments, power conductor 20 comprises a plurality of power conductors 20 and a set complimentary set of data communication interfaces 10a,10b associated with a predetermined subset of the plurality of power conductors 20, e.g. one set of data communication interfaces 10a,10b per each power conductor 20. Each power conductor 20 of the predetermined subset of the plurality of power conductors 20 is typically operatively coupled to subsea device 100 and remotely disposed device controller 200 via its associated complimentary set of data communication interfaces 10a,10b. As will be familiar to those or ordinary skill in data communications pathways arts, data communication interfaces 10a,10b may use one or more separate wires in one or more power conductors 20 to effect data communications.

[0013] Data transmitted along power conductors 20 typically comprise control and video telemetry data. In most embodiments, data transceiver 30 and one or more complimentary sets of data communication interfaces 10a,10b are configured to provide sufficient data bandwidth for control and video data in a baseband data transmission mode, a broadband data transmission mode, or a combination thereof. Data transceiver 30 and one or more of its complimentary set of data communication interfaces 10a,10b may also be configured to provide uni-directional and/or bi-directional using a predetermined data transmission protocol such as, by way of example and not limitation, Power Line Communications (PLC), Broadband over Power Lines (BPL), or the like, or a combination thereof.

[0014] Subsea device 100 may include a remotely operated vehicle, a subsea field pumping system, or the like, or a combination thereof.

[0015] **In the operation of exemplary embodiments,** commands and data appropriate to monitor and/or control subsea device 200 may be implemented by establishing a data communication path between subsea device 100 and remotely disposed device controller 200 over one or more power conductors 20 coupled to a respective set of a complimentary set of data communication interfaces 10a,10b, where one or more of such power conductors 20 is configured to provide power to subsea device 200 as well as data. Although a data communication pathway defined by power conductor 20 may be a primary means of data communication between device controller 200 and subsea device 100, one or more power conductors 20 may also provide data communication pathways along which data may be transmitted, in some cases along with power, via the complimentary set of data communication interfaces 10a,10b where the data communication pathway defines a redundant data communications pathway to subsea device 100 along with primary data communications pathway 42.

[0016] In certain embodiments, a data communication failure may be detected, e.g. primary data transmission pathway 42, and, upon such detection, data transmission switched from the failing data pathway 42 to data transmission over a data communication path defined by power conductor 20. The switching may be automatic or, in certain embodiments, manual.

[0017] The foregoing disclosure and description of the inventions are illustrative and explanatory. Various changes in the size, shape, and materials, as well as in the details of the illustrative construction and/or an illustrative method may be made without departing from the spirit of the invention.

CLAIMS:

We claim:

1) A method of controlling a subsea device, comprising:

a) establishing a data communication path between an electronically interrogatable component (110) of a subsea device (100) and a remotely disposed device controller (200) over a power conductor (20) operatively coupled to a complimentary set of data communication interfaces (10a,10b), the power conductor (20) configured to provide power to the subsea device (100), one of the data communication interfaces (10a) operatively in communication with the electronically interrogatable component and the other of the data communication interfaces (10b) operatively in communication with the remotely disposed device controller (200); and

b) using the data communication path to transmit data between the electronically interrogatable component (100) and the remotely disposed device controller (200) over the power conductor (20) via the complimentary set of data communication interfaces (10a,10b).

2) The method of Claim 1, wherein the subsea device (100) comprises a remotely operated vehicle.

3) The method of Claim 1, wherein the subsea device (100) comprises a subsea field pumping system.

4) The method of Claim 1, wherein the existing power conductor (20) comprises a power conductor disposed in an umbilical (42) or tether (42) attached to the subsea device (100).

5) The method of Claim 1, wherein the data comprise control data and video telemetry data.

6) The method of Claim 1, wherein the complimentary set of data communication interfaces (10a, 10b) comprise a complimentary set of power line modems,

7) The method of Claim 1, wherein the data communication interfaces (10a, 10b) are configured to effect unidirectional data transmission.

8) The method of Claim 1, wherein the data communication interfaces (10a, 10b) are configured to effect bi-directional data transmission.

9) The method of Claim 1, wherein the data communication path comprises a primary data communication pathway between the remotely disposed device controller (200) and the electronically interrogatable component (110).

10) The method of Claim 1, wherein the data communication path defines a redundant data communications path between the remotely disposed device controller (200) and the electronically interrogatable component (110), the method further comprising:

a) detecting a primary data transmission pathway (40) data communication failure; and

b) automatically switching data transmission from a primary data transmission pathway (42) to data transmission over the power conductor (20) data communication path when the primary data transmission pathway data communication failure is detected.

11) The method of Claim 1, wherein the data communication path defines a redundant data communications path between the remotely disposed device controller (200) and the electronically interrogatable component (110), the method further comprising:

a) detecting a primary data transmission pathway (40) data communication failure; and

b) manually switching data transmission from a primary data transmission pathway (42) to data transmission over the power conductor data communication path.

12) A system for controlling a subsea device (1), comprising:

a) a complimentary set of data communication interfaces (10a,10b) operatively coupled to an electronically interrogatable component (110) of a subsea device (100) and a remotely disposed device controller (200);

b) a power conductor (20) operatively coupled to the subsea device (100) and the remotely disposed device controller (200) via the complimentary set of data communication interfaces (10a,10b), the power conductor (20) defining a power conductor data pathway between the complimentary set of data communication interfaces (10a,10b); and

c) a data transceiver (30) operatively coupled to the electronically interrogatable component (110) and the remotely disposed device controller (200) via the complimentary set of data communication interfaces (10a,10b) over the power conductor (20).

13) The system for controlling a subsea device of Claim 12, wherein the power conductor (20) is configured to provide power to the subsea device (100).

14) The system for controlling a subsea device of Claim 12, wherein the power conductor (20) comprises:

a) a plurality of power conductors (20); and

b) a set of complimentary data communication interfaces (10a,10b) associated with a predetermined subset of the plurality of power conductors (20), each power conductor (20) of the predetermined subset of the plurality of power conductors (20) being operatively coupled to an electronically interrogatable component (110) of the subsea device (100) and the remotely disposed device controller (200) via its associated complimentary set of data communication interfaces (10a,10b).

15) The system for controlling a subsea device of Claim 12, wherein the data transceiver (30) and the complimentary set of data communication interfaces (10a,10b) are configured to provide sufficient bandwidth for control data and video data over the power conductor (20) data pathway.

16) The system for controlling a subsea device of Claim 12, wherein the data transceiver (30) and the complimentary set of data communication interfaces (10a,10b) are configured to provide either baseband or broadband data transmissions over the power conductor (20) data pathway.

17) The system for controlling a subsea device of Claim 12, wherein the data transceiver (30) and complimentary set of data communication interfaces (10a,10b) are configured to provide unidirectional or bidirectional data communications over the power conductor (20) data pathway using a predetermined data transmission protocol.

18) The system for controlling a subsea device of Claim 17, wherein the data transmission protocol comprises Power Line Communications (PLC) or Broadband over Power Lines (BPL).

19) The system for controlling a subsea device of Claim 12, further comprising a data transmission failure sensor (40) configured to detect a data transmission failure in a primary data communications pathway (42).

20) The system for controlling a subsea device of Claim 19, further comprising a data transmission switch (44) operatively in communication with the data transmission failure sensor (40) and the data transceiver (30), the data transmission switch (44) configured receive a data transmission failure in the primary data communications pathway (42) signal from the data transmission failure sensor (40) and cause the data transceiver (30) to transmit data over the power conductor (30) data pathway.

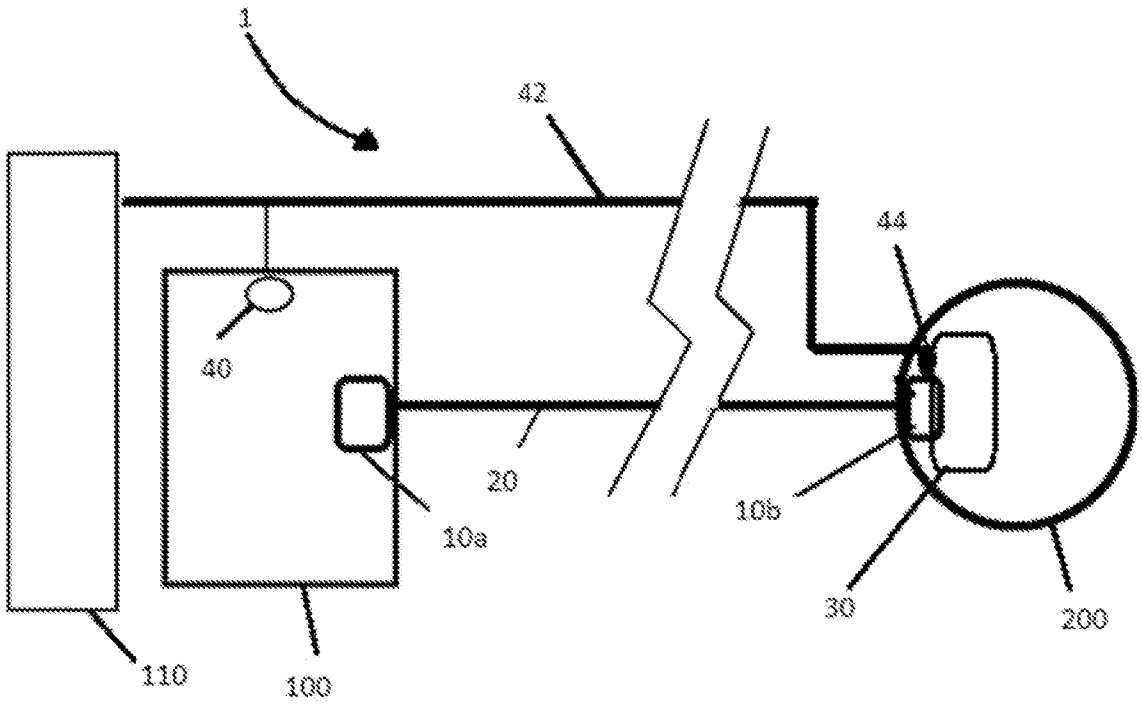

FIGURE 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 15/10430

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04B 13/02 (2015.01)
CPC - H04B 13/02, F42B 19/01, G01C 13/00
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)
CPC: H04B 13/02, F42B 19/01, G01C 13/00; IPC(8): H04B 13/02 (2015.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
340/850, 851, 855.8, 539.1, 539.3; 701/1, 400, 484, 31.5; 343/700R; CPC: G01R 33/025, G01V 3/081 (see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, PubWEST(PGPB,USPT,USOC,EPAB,JPAB), Google Scholar
terms: subsea, submarine, underwater, control, telemetric, telematic, powerline communications, transmission, data, modem, remotely operated vehicle, field pumping, Broadband, BPL, redundant, secondary, pathway, unidirectional, simplex, transfer, bidirectional, duplex.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,706,278 A (Robillard et al.) 06 January 1998 (06.01.1998), entire document, especially fig. 1, col 3, ln 5-36, col 4, ln 40 - col 6, ln 30, col 7, ln 17 - col 8, ln 7, col 9, ln 14-25, col 13, ln 14-36.	1, 6-10, 12-14, 16-20 ---------- 2-5, 11, 15
Y	US 2012/0175125 A1 (Krohn et al.) 12 July 2012 (12.07.2012), entire document, especially fig. 1, 4, para [0005], [0012], [0023]-[0027].	2-4
Y	US 2013/0073679 A1 (Fellman et al.) 21 March 2013 (21.03.2013), entire document, especially fig. 13, para [0006], [0146]-[0148], [0155].	5, 15
Y	US 5,329,520 A (Richardson) 12 July 1994 (12.07.1994), entire document, especially col 1, ln 46-59.	11
A	US 2010/0052940 A1 (Hesbol et al.) 04 March 2010 (04.03.2010), entire document.	1-20
A	US 2009/0310317 A1 (Horten et al.) 17 December 2009 (17.12.2009), entire document.	1-20
A	US 2008/0300742 A1 (Weaver et al.) 04 December 2008 (04.12.2008), entire document.	1-20

☐ Further documents are listed in the continuation of Box C. ☐

* 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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 March 2015 (01.03.2015)	27 MAR 2015
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)