

TESTING A FUSE

Field of the Invention

This invention relates to testing a fuse, in particular in a device for monitoring the condition of electrical insulation surrounding electrical conductors in a cable.

Background of the Invention

On-line monitoring of the characteristics of an electrical umbilical cable, such as an underwater (for example subsea) well control system umbilical cable, is performed by an umbilical monitoring device (UMD) which applies an electrical signal to conductors of the umbilical cable with respect to earth and uses various measuring techniques to ascertain that the characteristics of the umbilical cable are adequate for its intended remaining lifetime. The measuring techniques in such a UMD employ electronic amplifiers which are protected from excessive voltages on the live system by a fast blow fuse in series with the live system. The problem is that, if the fuse has blown, the UMD believes that it is connected to an umbilical cable with a high electrical insulation resistance, even if the insulation has completely failed.

Summary of the Invention

According to this invention from one aspect, there is provided a method of testing a fuse in apparatus for monitoring electrical insulation surrounding first and second electrical conductors in a cable, the fuse being connected to said conductors and the method comprising:

applying an electrical signal, with respect to a reference, to said fuse from a source;

obtaining a value for the resistance of said insulation with respect to said reference;

determining if said resistance value is greater than a fuse test resistance threshold and, if it is, causing application of the signal to cease; and

monitoring the decay of said signal to determine if the time for it to decay below a set value exceeds a set time limit, indicative of the fuse being satisfactory, or is less than said limit indicative of the fuse being blown.

According to this invention from another aspect, there is provided apparatus for monitoring electrical insulation surrounding first and second electrical conductors in a cable, the apparatus including a fuse for connection to said conductors, the apparatus comprising:

means for applying an electrical signal, with respect to a reference, to said fuse from a source;

means adapted for obtaining a value for the resistance value of said insulation with respect to said reference;

means adapted for determining if said resistance value is greater than a fuse test resistance threshold and, if it is, causing the application of the signal to cease; and

means adapted for monitoring the decay of said signal to determine if the time for it to decay below a set value exceeds a set time limit, indicative of the fuse being satisfactory, or is less than said limit, indicative of the fuse being blown.

Said cable could comprise an umbilical cable of an underwater well control system.

Said value for the resistance of said insulation with respect to said reference is typically obtained using a measurement of the voltage applied to said fuse with respect to said reference and a measurement of the current through said fuse, taking into account the effective resistance of means for measuring said voltage and the effective resistance of means for measuring said current.

Said fuse could be connected to each of said conductors by signal splitting means comprising first and second resistors. In this case, obtaining said value for the resistance of said insulation with respect to said reference typically takes into account the effective resistance of said signal splitting means.

Said reference is typically earth.

Brief Description of the Drawings

Fig. 1 is a schematic diagram of an embodiment of apparatus incorporating the invention; and

Fig. 2 is a circuit diagram for use in explaining the calculation of a value for insulation resistance.

Detailed Description of the Invention

The embodiment to be described operates in general as follows. Apparatus providing a UMD applies a measuring signal in the form of DC voltage via a fuse, and with reference to earth, to each of two conductors carrying AC in an umbilical cable which are surrounded by electrical insulation. The UMD derives a value for the resistance of the insulation between

the conductors and earth and, if this is determined to be above a fuse test resistance threshold value, it then causes application of the measuring signal to the fuse to cease. If the fuse is satisfactory and the UMD is in electrical connection with the umbilical cable, the capacitance of the insulation with reference to earth will be fully charged and it will take some time for the signal to decay. This decay is monitored and, if the time it takes to decay below a set limit is above a threshold value, the fuse test has passed (i.e. the fuse is satisfactory and provides electrical connectivity). If the fuse has blown and the UMD is not connected electrically to the umbilical cable, the signal will decay almost immediately, since the capacitance was not fully charged, from which the UMD determines that the fuse has blown.

Referring to Fig. 1, reference numeral 1 designates a DC voltage source (typically supplying a nominal 50 volts) in a UMD and reference numeral 2 designates an umbilical cable of a subsea well control system such as a subsea hydrocarbon well production control system. At least first and second electrical conductors 3 and 4 are in the umbilical cable 2, the conductors 3 and 4 supplying AC from a topside AC source 5 and a topside transformer 6 to subsea equipment via a subsea transformer 7. The conductors 3 and 4 are surrounded by electrical insulation 8 and the umbilical cable has a protective armour sheath 9 in contact with sea water and therefore at earth potential. The DC voltage source 1 can be connected between conductors 3 and 4 and earth via a switch 10 (when closed), current measuring circuitry 11 and a fuse 12 connected to the conductors via signal splitting circuitry comprising a resistor 13 connected to conductor 3 and an equal value resistor 14 connected to conductor 4. Typically, the connection to earth could be to the sheath 9. Since conductors 3 and 4 are connected across the secondary winding of transformer 6 and the primary winding of transformer 7, they effectively act as a single conductor as far as DC is concerned.

The voltage applied to fuse 12 with reference to earth is measured by voltage measuring circuitry 15 and the voltage measurement from circuitry 15 and the current measurement from circuitry 11 are supplied to insulation resistance measuring circuitry 16.

The method of testing the fuse 12 is as follows.

With switch 10 closed, a DC voltage is applied from source 1 and circuitry 11 and circuitry 15 feed current and voltage measurements to insulation measuring circuitry 16. The circuitry 16 includes a microprocessor which is programmed to calculate a value for the resistance of the insulation between conductors 3 and 4 and earth (see below). Circuitry 16 contains a threshold detector and, in response to the value of the insulation resistance exceeding a fuse test value, an output from circuitry 16 opens the switch 10, thus disconnecting the supply of DC, and enables a fuse monitoring stage represented by block 17. The fuse

monitoring stage is provided by an algorithm which is carried out by the microprocessor of circuitry 16 to monitor the decay of the voltage measured by circuitry 15.

If the fuse 12 is satisfactory, the capacitance of the insulation between conductors 3 and 4 and earth will have been fully charged and the voltage will take some time to decay, whereas if the fuse 12 is blown, the capacitance will not have been charged and the voltage will decay almost immediately.

The algorithm is such that the time it takes for the decaying voltage to fall below a set value is detected and if the time exceeds a set time limit (from which time the capacitance of the insulation between conductors 3 and 4 and earth can be calculated), a fuse satisfactory signal is output from a port 18 and if the time is less than the set limit, a fuse fail (blown) signal is output from a port 19.

The calculation of a value for the resistance of the insulation between conductors 3 and 4 and earth by the microprocessor of circuitry 16 is as follows. Fig. 2 is a simplified circuit diagram of the above system as far as DC is concerned, in which:

I_R is a value for the insulation resistance between conductors 3 and 4 and earth;

R_T is a total resistance value, as measured by circuitry 16 as the voltage measured by circuitry 15 divided by the current measured by circuitry 11;

R_S is the known effective resistance value of the splitting circuitry, namely half of the value of each of resistors 13 and 14;

R_V is the known effective resistance value of voltage measuring circuitry 15; and

R_C is the known effective resistance value of the current measuring circuitry 11.

Insulation measuring circuitry 16 calculates I_R from:

$$I_R = \frac{R_T R_V + R_T R_S - R_C R_V - R_C R_S - R_V R_S}{R_C + R_V - R_T}$$

Instead of being connected to signal splitting circuitry, the fuse 12 could be connected to conductors 3 and 4 via a centre tap of the secondary winding of transformer 6. Also, the conductors 3 and 4 could be carrying DC instead of AC in which case signal splitting circuitry is necessary.

An advantage of using the invention is provision of knowledge that a fuse in a UMD is satisfactory while testing on a live system without having to shut down the system, remove the fuse and test it in isolation.

CLAIMS

1. A method of testing a fuse (12) in apparatus for monitoring electrical insulation surrounding first and second electrical conductors (3,4) in a cable (2), the fuse being connected to said conductors and the method comprising:

applying an electrical signal, with respect to a reference, to said fuse from a source (1):

obtaining a value for the resistance of said insulation with respect to said reference;

determining if said resistance value is greater than a fuse test resistance threshold and, if it is, causing application of the electrical signal to cease; and

monitoring the decay of said electrical signal to determine if the time for it to decay below a set value exceeds a set time limit, indicative of the fuse being satisfactory, or is less than said limit indicative of the fuse being blown.

2. A method according to claim 1, wherein said cable (2) comprises an umbilical cable of an underwater well control system.
3. A method according to claim 1 or 2, wherein said value for the resistance of said insulation (8) with respect to said reference is obtained using a measurement of the voltage applied to said fuse (12) with respect to said reference and a measurement of the current through said fuse, taking into account the effective resistance of means (15) for measuring said voltage and the effective resistance of means (11) for measuring said current.
4. A method according to any preceding claim, wherein said fuse (12) is connected to each of said conductors (3,4) by signal splitting means comprising first and second resistors (13,14).
5. A method according to claim 4, wherein obtaining said value for the resistance of said insulation (8) with respect to said reference takes into account the effective resistance of said signal splitting means (13,14).
6. A method according to any preceding claim, wherein said reference is earth.
7. Apparatus for monitoring electrical insulation (8) surrounding first and second electrical conductors (3,4) in a cable (2), the apparatus including a fuse (12) for connection to said conductors, the apparatus comprising:

means (10) for applying an electrical signal, with respect to a reference, to said fuse from a source (1);

means (11,12,15,16) adapted for obtaining a value for the resistance of said insulation with respect to said reference;

means (16) adapted for determining if said resistance value is greater than a fuse test resistance threshold and, if it is, causing the application of the electrical signal to cease; and

means (16,17) adapted for monitoring the decay of said electrical signal to determine if the time for it to decay below a set value exceeds a set time limit, indicative of the fuse being satisfactory, or is less than said limit, indicative of the fuse being blown.

8. Apparatus according to claim 7, adapted so that said value for the resistance of said insulation (8) with respect to said reference is obtained using a measurement of the voltage applied to said fuse (12) with respect to said reference and a measurement of the current through said fuse, taking in account the effective resistance of means (15) for measuring said voltage and the effective resistance of means (11) for measuring said current.
9. Apparatus according to claim 7 or 8, wherein said fuse (12) is connected to each of said conductors (3,4) by signal splitting means comprising first and second resistors (13,14).
10. Apparatus according to claim 9, adapted so that obtaining said value for the resistance of said insulation (8) with respect to said reference takes into account the effective resistance of said signal splitting means (13,14).