A REAL TIME FAULT DIAGNOSIS AND LOCATING METHOD USED IN SUBMARINE CABLE SYSTEMS

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Abstract: As most faults in submarine cable systems are caused by anchoring or trawlers, it is necessarily required to find the related vessels for damages declare. However, vessels' continuous moving causes them hard to be tracked unless faults could be located in time. In this paper, a software based real time fault-locating method is introduced and could be beneficial in this case.

1 INTRODUCTION

Nowadays, most cable faults are caused by anchoring or trawlers, if it needs a long time to locate the faults after their occurrences, the suspect vessels would have possibly sailed away from fault areas, making it hard, especially at night, to track vessels and declare damages for cable carriers.

In this paper, we introduce a software based real time diagnosis method which could locate the faults by automatic alarm analysis and send fault reports with geographic information within 20 minutes. It could be a great help for cable carriers to lower the risk of unnecessary equipment losses caused by failing to find suspect vessels for damages.

2 A CONCEPT INTRODUCED

Currently there is no real time fault diagnosis and locating method in most monitoring systems. For a submarine cable system, site equipment, e.g. SLTE, PFE, etc., is usually supervised by network management systems (NMS) [1] to collect performances and alarms, which are related to equipment or services and have no direct connection to faults or fault diagnosis. And in most fault cases, even an existence of a cable fault has been determined, it still needs several hours or more, based on the system configuration and the experiences of operators, to locate the accurate fault positions. And, to help perform tracks, accurate fault information, especially the geographic fault positions, needs to be sent to marine police or similar units in time. Nevertheless, manual operation of this fault diagnosis and locating would be low-efficient. The following is its main process:

1. Check and analyze system alarms and performances to determine the fault type.
2. Perform locating test or calculation based on PFEs' voltages according to the fault type and translate the faults' length positions to geographic positions
3. Send the fault reports, by means of short messages, emails, etc., to the end users, etc.

A software based real time fault diagnosis and locating method could work in the similar procedure. As all equipment alarms and performance data are monitored and collected in NMS systems, this method could be implemented in these systems.

Here is the summary of prerequisites for its implementation:

• All equipment alarms and performances, including PFEs, are accessible.

• Probe equipment, e.g. COTDR, etc. are controllable.

• Cable deployment information is provided to support translation from lengths in cables to geographic positions.

• Various notification methods, e.g. short messages, e-mails, could be used to send fault reports.

3 MAIN FAULTS AND ALARM PATTERNS

There are two main damages in a cable fault: conductor damages and fiber damages. A cable fault may contain either type or both, which, together with fault positions, can produce a numerous combination of cable faults scenarios. Conductor damages have two subtypes: the power-feeding structure, which may be broken or not, is exposed to the sea and becomes a sea ground to the power-feeding path, also called shunt fault; or the power-feeding structure is broken but not exposed to the sea, also named open circuit. Fiber damages could have one or more fiber breaks or large attenuations which may belong to the same fiber pair or different fiber pairs.

As single fault scenarios are the numerous and their complexities are relatively lower than multiple ones, this method supports single fault scenarios only.

All possible faults could be classified into several main categories according to the alarm patterns they produce.

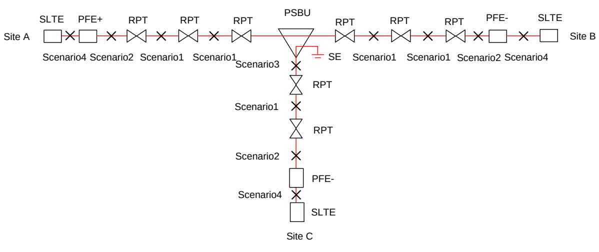

Figure 1 Scenarios of cable breaks

Given the upper configuration as an example, there are four main types of cable break scenarios, and each scenario's feature alarms could be easily clarified. Shunt faults scenarios are similar and could be analyzed in the same way.

Although most cable faults could be distinguished by alarm patterns, there are some faults which produce no alarms. For example, shunt faults near the sea earth, in which power-feeding structure is exposed to the sea but not broken, no alarms will be generated.

4 A REAL TIME DIAGNOSIS AND LOCATING METHOD

When a specific fault occur in a submarine cable system, site equipment, e.g. SLTE, PFE, will generate related alarms, which could also be analyzed to diagnose the existing fault. Take a cable break as an example where both conductor structure in the cable and all fibers are broken. In this condition, alarms such as loss of signal (R-LOS) and voltage alarm could be generated in SLTEs and PFEs separately. By analyzing alarms generated in equipment, existences of faults in the cable system could be determined, and a fast fault locating test could be started to get the accurate position within 15 minutes. After the translating of the fault position, the fault report could be sent to the user by short message, etc., that could be a great convenience for routine maintenance. This procedure is shown in Figure 2 and 3.

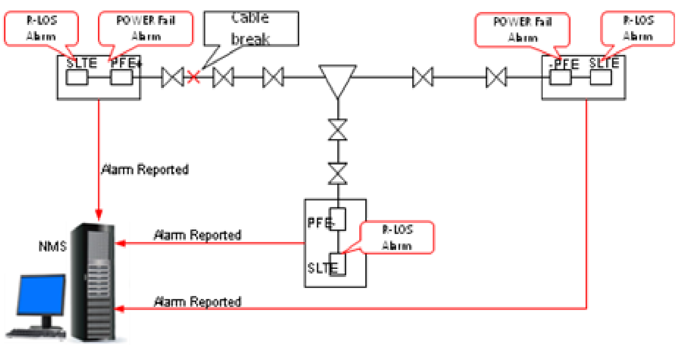

Figure 2 Fault diagnosis and locating on alarms

Figure 3 Fault reports

Another example is about shunt fault, where services might be unaffected but some abnormal will occur in PFE voltages. In this case, fault positions in cable could be calculated by analysing PFEs' voltage performance changes [3].

In this method, all equipment and service alarms are reported and filtered to determine the fault scenarios, or the fault types, as each matches a specific alarm sequence called alarm patterns. Figure 4 and 5 are fault scenarios and their related alarms in each site.

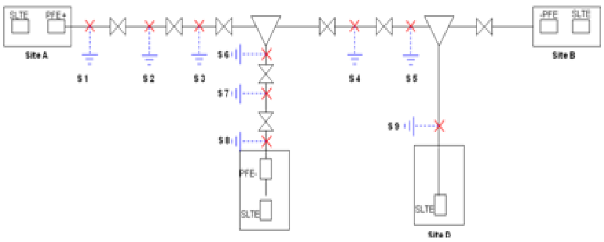

Figure 4 Analysis of fault scenarios

Shunt fault	SLTE				PFE		
	Site A	Site B	Site C	Site D	Site A	Site B	Site C
scenario1					Voltage Alarm	Voltage Alarm	
Scenario2					Voltage Alarm	Voltage Alarm	
Scenario3							
Scenario4					Voltage Alarm	Voltage Alarm	
Scenario5							
Scenario6							
Scenario7	All or partial R-LOS	All or partial R-LOS	All R-LOS	All or partial R-LOS			Voltage Alarm
Scenario8	All or partial R-LOS	All or partial R-LOS	All R-LOS	All or partial R-LOS			Voltage Alarm
scenario9							

Figure 5 Alarm analysis

After the fault scenarios are acquired by alarm pattern analysis, this method gets fault locations in length by performing OTDR/COTDR testing [2, 4], or evaluating fault location according to PFEs' voltages [3], just as those manually handled in traditional ways. As anchoring or trawlers faults are usually not far away from coastlines, fast COTDR test, e.g. 15 minutes fast fault locating, could be applied to get the fault locations as fast as possible. Technically, evaluating of fault positions according to PFEs' voltages is a calculation work and causes little time. But these testing or calculation can only get fault positions in length, to get the geographic positions of faults, system deployment or geographic information of cables should be used to translate the faults in length to geographic positions, which is a common function supported by most GIS systems. Tolerance should also be considered in this process, as each locating stage could bring in some errors, especially for those with cable repairmen, extra cables have been added and thus changed the deployment in geography. After all fault positions and geographic context have gotten, with GIS information supported, fault reports could be properly organized for end users. And multiple ways of communication, e.g. short message, email, could be used to send the fault reports to users registered or specified.

Our implementation of this method is based on U2000, and uses all the techniques introduced in this paper. To be more attractive and meaningful for users, faults reports could also be displayed with geography information integrated, as shown in Figure 6 and Figure 7.

Figure 6 Demonstration of a cable break fault report

Figure 7 Demonstration of a shunt fault report

5 CONCLUSIONS

In this paper, a software based real time diagnosis method is introduced with technical analysis and demonstrated with U2000 NMS. Different fault scenarios and alarm analysis are also introduced, which could be the technical base of other automatic fault diagnosis systems.

As an automatic and real time diagnosis method, it could greatly improve the cable carriers' response promptness to faults and shorten the fault locating time as much as possible, especially for faults caused by fishing or anchoring, and be a useful supporting tool for tracking vessels and for commercial damages negotiations.

6 REFERENCES

[1] Katsuo Suzuki, "Undersea Fiber Communication Systems", 378-340

[2] Neville J. Hazell, Christopher E. Little, "Undersea Fiber Communication Systems", 353

[3] Neville J. Hazell, Christopher E. Little, "Undersea Fiber Communication Systems", 368-370

[4] Olivier Gautheron and Omar Ait Sab, "Undersea Fiber Communication Systems", 170