APPLICATION OF POWER SWITCHING FOR ALTERNATIVE LAND CABLE PROTECTION BETWEEN CABLE LANDING STATION AND BEACH MAN HOLE IN SUBMARINE NETWORKS

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Abstract: This paper describes the case for land cable section protection with the application of robust high voltage power switching. Based on the factors like, power switching architectures, reliability aspects together with power switching configurations we describe an operation that has been commercially deployed for over 3 years. The solution provides a feasible methodology to restore cable cut faults between the beach man hole and cable landing station and opens up future designs for automatic restoration as well as integrated optical switching as two possible avenues. In today's challenging submarine environment where some regions experience disruptions, or need maintenance operations the ability to restore power and avoid loss of traffic, has both operational and commercial benefits.

1. INTRODUCTION

Although the macroeconomic has obviously impacted the increase speed of the overall international bandwidth and investment of submarine fibre optical cable industry during the past years, the developments on the demand for new submarine cable system are still very fast. However the main market has already moved to the developing regions obviously. From the latest public industry report[1] it can be shown, that the last five years from 2008 to 2012 has witnessed over 50% of new investment in submarine fibre optical cable system, has been directed to Africa, Middle East and Asia.

With more and more submarine cable systems being constructed within these developing countries, all kinds of engineering construction and other human activities are very frequent which helps with the high-speed telecommunications infrastructure and economic development. The construction often involves civil works, working against tight deadlines, those in rapid expansion projects fail to request the relevant information about the existing service infrastructure. Such rapid construction operations often have some potential drawbacks and when in the vicinity of the existing installed terrestrial cable, places increased risk on the submarine cable system connectivity. The end result when the land cable is cut, is both loss of system power and all service outages.

Failure causes vary from different external aggression but when the failure on the land cable takes place, the recovery process can be slow. These main causes of cable damage are excavators, horizontal drilling, vertical drilling, traffic and heavy-duty vehicles, vandalism and etc. Statistics show that more than half of the failures are caused by engineering construction work.

For a repeatered cable system, the power feeding equipment in the cable landing station, supplies the power to the submerged repeater through the land cable section between the cable landing station and beach man hole. So if any damages or a fault occurs on the land cable section, the whole submarine cable system power feeding will shut down along with loss of all live service traffic. In case of the cable damage the service recovery process will need a significant time, normally several days with the fault investigation, repair and testing along with health and safety aspects. Considering the general importance of the service over the submarine cable system and the desire to improve the availability of the system, we will discuss the appropriate protection on the land cable section and the way to realize the quick service recovery. Several levels of protection and switching solution focus on land cable and a typical application case for a repeatered submarine cable system is introduced.

2. BASIC SOLUTION

On the land cable it is known that there are many installation and mechanical protection methods. The most commonly used installation methods are direct burial, horizontal directional drilling, laying in pipes, laying in ducts and etc. The different installation methods provide different levels of mechanical protection, however this normally is not enough because of the area in which the cable to be installed may have access constraints, such as the heavy traffic, rocks, river, city area. So the basic solution is proposed with 1+1 route backup for the land cable section. The two land cables go through diverse routing and may steer clear of risky areas to avoid single points of failure. With this arrangement, if one land cable (path-a) had a cut or failure the dedicated power switching units deployed both in the beach man hole and the cable landing station can be switched to second land cable (path-b) route, as to maintain the system power feeding to the submerged plant. The Figure 1 shows the simplified diagram of the land section for a repeatered submarine cable system.

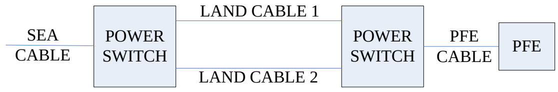

Figure 1: Land Route 1+1 Protection

The electrical power path and switches in the beach man hole can be configured as the below Figure 2.

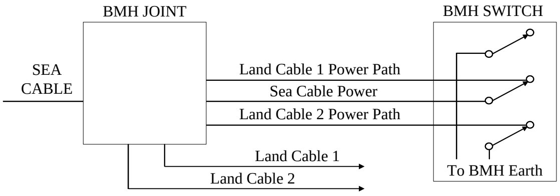

Figure 2: Power Path Configuration in the Beach Manhole

The optical path configuration is shown in below the Figure 3 for example. As we are known normally there are several fibre pairs redundant for a new build repeatered system, so these fibre pairs can be used as backup optical path to alternative land cable route. This can be considered as a 1:1 backup on each fiber pair.

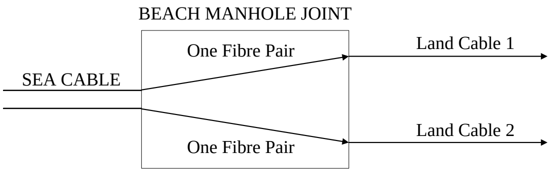

Figure 3: Optical Path Configuration

So the associated electrical and optical configuration in the cable terminal station is shown in the Figure 4 as below.

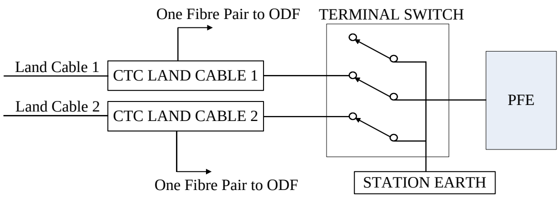

Figure 4: Electrical Configuration in the Cable Landing Station

Based on the configurations as above, the two land cables go through different routes between the beach and the terminal station. In case of external aggressive and the land cable of the working path is impacted, the whole submarine cable system can be recovered quickly. The power switching to the backup route from the damaged route compared to the time it takes for fault location and repair is much shorter. When the power fed equipment for the submerged plant is switched to feeding from the standby land cable route, the initial land cable is connected to the system earth. More important this also allows safe fault investigation, repair and maintenance testing with no impact to the services on the whole submarine cable system.

However to implement such a high voltage power switching application on a real repeatered system, there are many operational challenges especially high voltage power switching within a beach man hole. Safety and reliability of the whole system design life, robust design for the application environment conditions and etc all need to be considered carefully.

3. APPLICATION CASE

Respect to the real requirement and importance on the land route protection, this power switching solution has been successfully deployed on one repeatered submarine cable system.

On this system, two fibre pairs from the submarine cable are divided into two diverse land cable routes, shown in Figure 1. One fibre pair is on the main route and lit with live services. The other fibre pair remains as standby route and noted as a dark fibre pair. The power switches used in the cable landing station and the beach man hole are a rotary high voltage power switch design and customized to operate at 3.6KV and validated up to 30KV. The power switching unit is also designed with industry standard ingress protection to be suitable for mounting either in cable landing station and beach man hole, which as we know is often under harsh conditions – such as sea water and other non-idea conditions. Factors like these places stringent requirements and several operational challenges on the switch design and mechanics of operation.

The following Figure 5 is the picture post installation of the power switching unit (left grey box) and the cable terminal splicing units (right bottom two red boxes) in the cable terminal station.

Figure 5: Power Switch and CTC in CLS

The overview of the power switching unit box and the coiling frame mounted in the beach man hole is as shown in Figure 6, during installation

Figure 6: Power Switch in Beach Manhole

The Figure 7 is the picture showing the inside details of the power switching unit installed in the beach man hole.

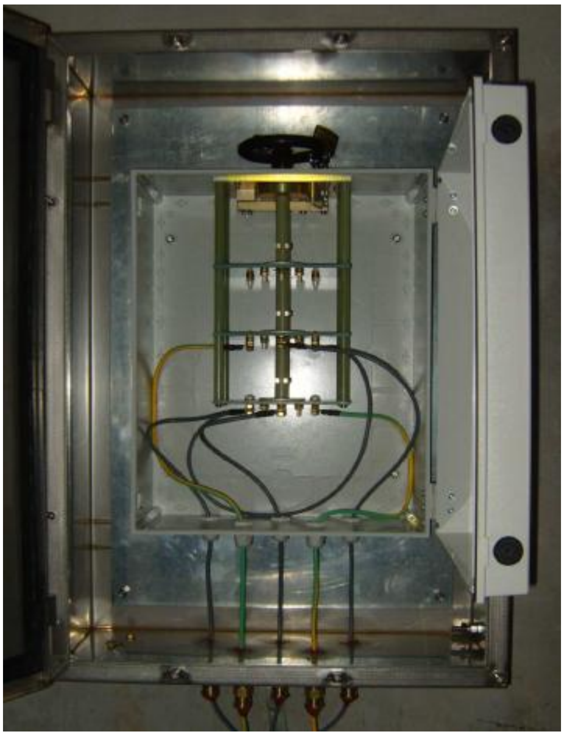

Figure 7: Power Switch in Beach Manhole

This rotary switch is in simple mechanical design and low cost but results in high reliability, simple operation and stability. The switch operates at a nominal high voltage switching incoming marine cable between two diverse land cables. Whilst one land cable is active, the other land cable is earthed and vice-versa for the second position. The mid position 'OFF' can be padlocked off on the manually operated hand wheel outside for maintenance purposes.

In addition, each rotary switch has a reinforced chassis design utilizing fire retardant anti-tracking coated epoxy glass insulation. Heavy duty contacts are made of highly conductive yet weld resistant alloy with high contact closing force. This high force gives the rotary switches high momentary current capability and a reputation for their ability to withstand high shock and vibration as well as other severe environmental conditions.

For the power switching unit in the cable landing station, the polycarbonate enclosure which houses the high voltage switch is rated at IP65 ingress protection to IEC 60529. In the beach man hole, there is an additional outer stainless steel enclosure offers environmental protection to IP68 except for the inner enclosure same as the one used in cable landing station.

On the safety aspect, this rotary power switch can help the engineers to meet OSHA (Occupational Safety and Health Administration Regulations) and other safety organization regulations concerning protection for personnel from the danger of high voltage. To accomplish this, the rotary switch is designed with manually operated actuators that include safety cam detent for positive contact positioning and safety interlocks. Complementing this feature is a design concept unique to these rotaries. The high voltage rotary switch is built with a lockable centre off position for safe working practices, i.e. maintenance procedures on the land cable.

4. FUTURE DIRECTIONS

Regarding the power switching function and various requirements, there are many different optional configurations that can be considered in future application of new build repeatered submarine cable system, or infact upgrades to existing ones

For example on the optical path there are more flexible options which overcome some limitations with this case presented here. To increase the availability of the all fibre pairs, one small modification could be to insert the passive 50:50 coupler for example as below Figure 8 on the beach man hole joint.

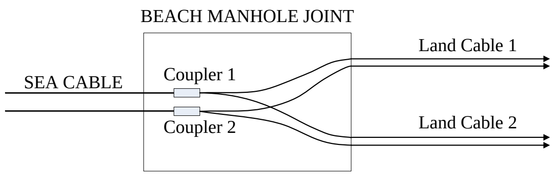

Figure 8: Optical Path Improvement

Each fibre pair would share half of the optical signal power to each land cable route, thus introducing 3~4dB insertion loss to the first/last section of the submarine repeater system. In the terminal station, the same modification is required on the point of the optical signal feeding from terminal equipment to the land cables. Whilst this may have a power budget impact, with advancements in terminal equipment the loss could be overcome, in any case it's clearly a tradeoff. Then the optical path is on 1+1 backup for each fiber pair. Also the couplers can be replaced with 1x2 optical switches which will provide additional flexibility and also improvement on the optical power budget for the segment between the first/last repeater and the terminal station.

For a longer repeatered system, the voltage rating may place higher demands on the switch, although this depends upon the cable length and repeater electrical characteristics. This places some potential design challenges on the voltage requirements of the power switch, so improvement would be needed in such cases. Based on the rotary switch design introduced above and with slight modifications on the inner enclosure, the high voltage switch can be immersed in insulating oil, fluid or gas, the voltage withstand value will be at least double increased and the interrupt capability will be much greater.

However on the scenario that requires the system traffic to be recovered quickly the manually operated rotary power switch may not enough. Hence the remote operated electrical power switch and optical switching would be necessary, although this would add some extra cost. These are not complex matters but more of a case to engineer a design into a product. Furthermore, the electrical and optical switching can be integrated to the network management system. Then under fault conditions as an example, the protection switching from the active to the standby land cable can be controlled by the network management system from the terminal stations or the network operation center. Given the stringent safety aspects with power feed equipment, it's pretty certain some aspect will require human intervention, just to be on the safe side! The product presented in this paper was designed, built and has been in commercial service, its roadmap and development is interesting as it opens up an innovative solution for both new submarine cable system build and upgrades to existing plant.

Providing a fully automated solution managed by the network management system and taking away the headache, often faced by system owners may not be that far away.

5. REFERENCES

[1] Submarine Telecoms Forum, Submarine Cable Industry Report, Issue 1, July 2012, Page 16.
[2] ANSI/IEC 60529-2004, Degrees of Protection Provided by Enclosures (IP Code)