Effective Application of KCS Cable Probe for Localizing Submarine Telecommunication and Power Cables

Takaharu Etou, Yukihiro Fujii, Nobuo Fukushima (Kokusai Cable Ship Co., Ltd.), Yuichi Shirasaki (Marine Eco Tech Ltd.)
Email: ta-etou@k-kcs.co.jp

Kokusai Cable Ship Co., Ltd. 6th Floor, Kawasaki Frontier Bldg., 11-2, Ekimae Hon-cho Kawasaki-ku, Kawasaki, Kanagawa 210-0007 Japan

Abstract: KCS Cable Probe made high accuracy localization possible with easy operation by a diver and simultaneously measures a burial depth of a buried cable on the beach or inshore area. It detects a low frequency magnetic field generated around a cable and localizes a buried cable position by measuring the distribution of the magnetic field which is generated by the electroding. This development enabled the existing cables to be detected without excavation work and the risks to be eliminated by far at the same time. The Cable Probe can be used to locate submarine telecommunication and power cables.

1. Introduction

Recent years, submarine cable landing stations accommodate many cables from different network systems and it is essential to get a full picture of where existing cables are laid when landing a new cable in order to eliminate the risks of damaging the existing cables. Up until the portable KCS Cable Probe was developed by Kokusai Cable Ship Co., Ltd. over 15 years ago, the only way to localize existing buried cables was to visually confirm the cables by prospecting which involves substantial risk and it has become widely known as one of the most effective methods for cable localization.

Fig. 1: Cable Probe (left), Diver with Cable Probe (right)

A cable probe which is capable of localizing a position of buried cable already existed 15 years ago. However, it did not have the function to measure a burial depth and KCS focused on "measuring a burial depth" issue as this could open many doors for localizing cables more effectively. Based on this concept, KCS has developed a new portable Cable Probe which can determine a burial depth with a high degree of accuracy and also can be handled easily by a diver on the beach or at inshore area. It has been applied to localize existing cables at many sites for many years up to the present.

2. Specifications of Cable Probe

The portable Cable Probe can measure and display a buried cable position as well as a burial depth under the seafloor. The measured figure with the measurement time are recorded to data storage device of the Cable Probe. The data can be downloaded onto PC.

1) Applicable water depth:
Maximum100 m

2) Dimension: 160 mm dia. x 840 mm
3) Weight: 7 kgf (in air) / 1 kgf (in water)
4) Material: acrylic resin
5) Frequency of electrode current: 25 Hz
6) Maximum measuring range:
5 m (in case of 50mA p-p current)
7) Accuracy of measuring burial depth:
Within ±1% of measured depth
8) Indications contents of LED bar graph:
Strength of magnetic field,
"PEAK" and "NULL"
9) Indications of LED numerical:
Burial depth
10) Battery life: Approx. 4 hours
(In case of 6 AA alkaline batteries)
11) Operating temperature: -10°C - 40°C

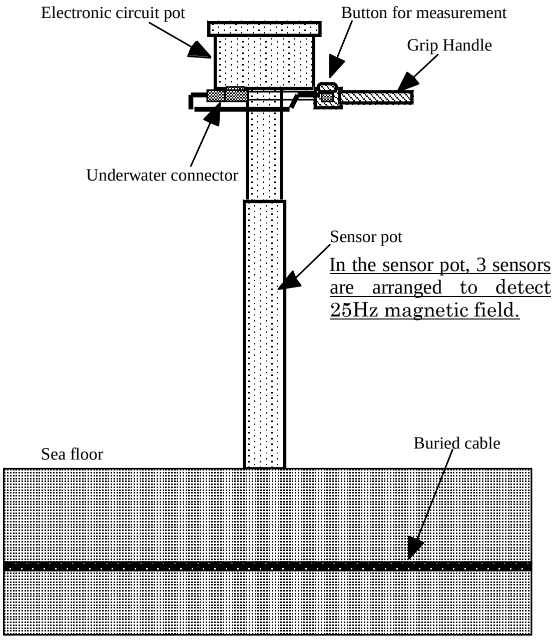

Fig. 2: Structure of Cable Probe

3. Operating Principles

If the current "I" flow through the cable, the magnetic field ***dH*** at a distance ***r*** from a line element ***ds*** carrying current "I" is written by Biot-Savart Law;

$$\boldsymbol{dH} = \frac{\boldsymbol{Ids} \times \boldsymbol{r}}{4\pi \boldsymbol{r}^3} \quad \cdots\cdots(1)$$

The direction of the magnetic field ***dH*** is perpendicular to the line element ***ds*** as well as radius ***r***.

In case that the cable length is extremely larger than "**r**", and the frequency of current is the audio band, the magnetic field generated around the cable "H" 〔A/m〕 at the length "R" 〔m〕 from the cable is integrated based on the above expression (1) as outlined in Figure 3. Thus "H" 〔A/m〕 is defined in the following expression (2) by Ampere's Law;

$$H = \frac{I}{2 \cdot \pi \cdot R} \quad \cdots\cdots(2)$$

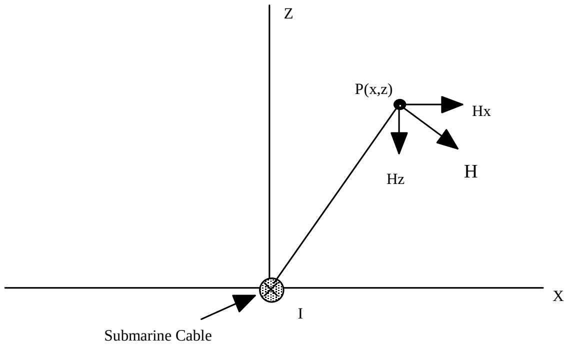

Fig.3: Magnetic Field generated around the Cable

For example, in case that the cable is buried 1 meter under the seafloor, the magnetic field strength "H" 〔A/m〕 around the cable at point P (on the seafloor) where moved -10 meters and +10 meters on the cross direction of the laid cable and the supplied current is 0.1 ampere, the result of calculation of the strength of magnetic field "H" 〔A/m〕 around the cable which solved to the horizontal component "Hx" and the vertical component "Hz" is described in Figure 4.

(In Figure 4, the vertical axis indicates magnetic flux density (nT: nanotesla) to be used as practical argument instead of magnetic field strength "H" 〔A/m〕.)

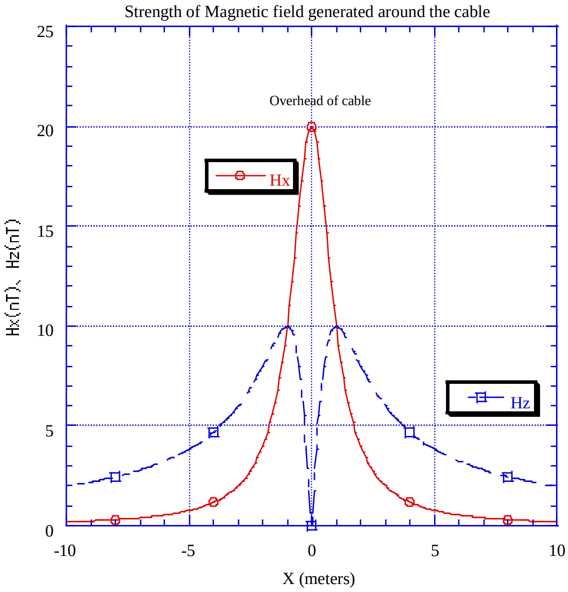

Fig.4: Strength of Magnetic Field around the Cable

In the Figure 4, it describes that horizontal component "Hx" of the magnetic field strength "H" 〔A/m〕 around the cable becomes maximum (PEAK) and vertical component "Hz" becomes Zero (Null) when the position of the Cable Probe is just above the cable. This phenomenon can be used to obtain the position of buried cable.

Special attention is required to the current "I" of the above expression (2). In case that cable type is unarmored cable, the return current from the cable end in the sea is spatially spread into the sea out and returned to the sea earth of the electroding signal generator. The current "I" of expression (2) is approximately equal to the supplied current "I" as shown in Figure 5 because of the low frequency condition.

On the other hand, in case of armored cable which is usually used at inshore area, a part of return current is returned to the armor wires described in Figure 6. Thus the phase of magnetic field generated by the return current via armor wires is to be opposite phase of magnetic field generated by supplied current, and then the composite magnetic field "H" around the cable is reduced. This returned current value via armor wires differs depending on the structure of armor wires, frequency and water depth, etc., and then an effective current (inject current - returned current) cannot be obtained precisely.

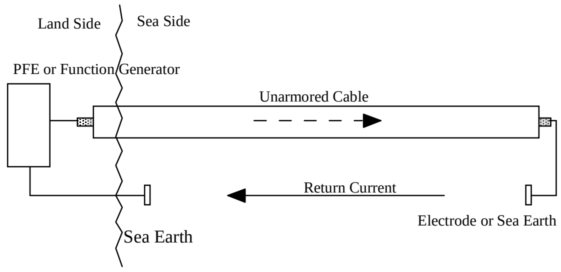

Fig.5: In case of Unarmored Cable

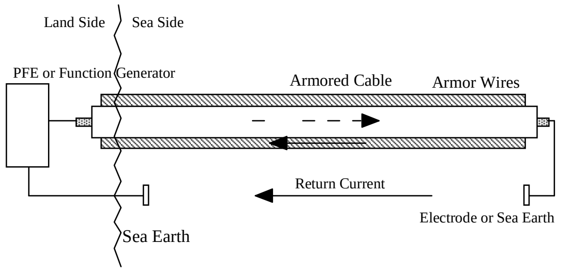

Fig.6: In case of Armored Cable

In case that the indication of current value (effective current) is clear, R (equivalent burial depth when the position of the Cable Probe is just above the cable) can be obtained based on the above expression (2). However the effective current value cannot be obtained in most cases because the type of laid cable at inshore area is armored cable.

The Cable Probe has adopted a new method to measure a burial depth accurately and easily although the effective current "I" cannot be calculated precisely.

Figure 2 shows the structure of the Cable Probe. Two sensors which detect the only horizontal component "Hx" of the magnetic field strength "H" 〔A/m〕 around the cable and another sensor which detects the only vertical component "Hz" are stored in a sensor pot. These detected signals are processed and displayed on the top of the Cable Probe as “PEAK” and “NULL” described in Figure 7. Based on the phenomenon showed in Figure 4, it is easy to locate the cable just above the buried cable. Also “PEAK” indication is useful for figuring out the direction of buried cable.

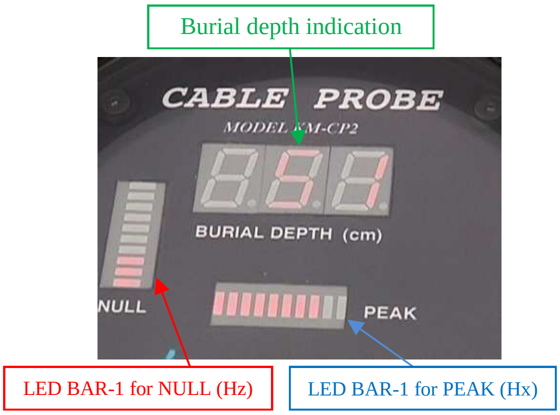

Fig. 7: Display of Cable Probe

Two sensors which detect the only horizontal component “Hx” of the magnetic field strength “H” around the cable are stored in an upper part and a lower part of a sensor pot. When the Cable Probe is positioned just above the buried cable, the burial depth is calculated by the difference between each horizontal component “Hx” detected at each sensor and the Probe indicates the BURIAL DEPTH (cm) on the LED display.

4. Example of Use

4.1 Localization of existing buried cables

The Cable Probe localizes existing buried cables and enable to install a new cable to a cable landing station which accommodates many cables without visually confirming existing cables or excavating work.

Figure 8 shows a backhoe burying a new telecommunications cable while the Cable Probe localizing existing buried cables on the beach in front of a cable landing station. These works can be done in parallel.

Fig. 8: Existing Cable Localization

4.2 Cable Fault Point Localization

Figure 9 shows the outline of the cable fault point localization by diver with the Cable Probe.

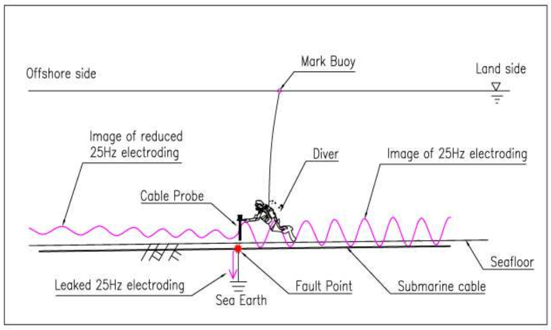

Fig. 9: Fault Localization by diver with Cable Probe

In case of power feeding line, normally copper conductor, is shorted to the sea, large portion of the current which injected to the cable from an electroding signal generator or similar equipment such as a power feeding equipment installed at a cable landing station will be leaked to the sea out from the shorted point of the power feeding line and which means that the indication of the detected signal strength of the Cable Probe will be also largely reduced. Figure 10 describes the fault point that was actually localized by the Cable Probe with the procedure explained in the above. This localized fault point (shunt fault) has armor wire breaks with a 3mm in diameter of a pinhole on the polyethylene insulation of the laid cable where positioned in water depth 1.5 meters and rocky area .

Fig. 10 : Localized Fault Point (Shunt Fault)

4.3 Application to Power Cables

As described earlier, operational principal of the portable Cable Probe is to detect the magnetic field generated by the supplied 25 Hz current. Therefore it can localize a buried cable position and measure a burial depth easily.

Originally, the Cable Probe was planned to be used for telecommunication cable only but recent years, the Cable Probe is applied for localizing power cables as the supply of 25Hz electroding current via a power feeding line, normally copper conductor, is possible in the same way as telecommunication cables.

Figure 11 is the photo of electroding from the generator set under the tent to the three layer structure power cable on the power pole.

Fig.11: Electroding to Power Cable

5. Conclusion

It has been over 15 years since the development of the KCS Cable Probe and it played an important role in many different cable landing sites and in many different scenes for both telecommunications and power cables.

KCS challenge and contribution to the submarine cable industry continue by considering the following new functions and functional improvements.

1) Expanding the scope of application for telecommunication and power cables by additional function which can be detected other frequency (15Hz, 20Hz, (25Hz), 50Hz, 60Hz)

2) Expanding the detection area by additional function of "automatic gain control (AGC)"

3) Functional improvement for long hours of usage by power saving

4) Additional measurement function for water depth and azimuth direction.

6. Acknowledgement

We would like to extend sincere appreciation to Ms. Kaori Shikinaka of KCS for her great contributions to this paper.