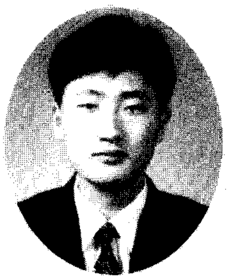
Ship-Shore Communication System Through 850nm VCSEL Converter



한정우 (Jeong-Woo, Han)

- 1972년 11월 28일생
- 1998년 전남대학교 화학공학과 대학원 졸업
- 현 재 : General marine business. Inc 과장 Engineer
- 관심분야 : process control, communication
- 연 락 처 : 052-254-5215 017-571-4947
- Email : jwhan@generalmarine.biz

곽정호 (Chong-Ho, Kwak)

- 1963년 6월 25일생
- 1987년 한국 해양대학교 기관학과 졸업
- 현 재 : General marine business. Inc 이사, CTO
- 관심분야 : communication, Process
- 연 락 처 : 052-254-5215 016-588-3817
- Email : kamsei50@generalmarine.biz

1 Introduction

Ship/Shore Communication System (hereafter called SSCLS) between LNG carriers and the shore terminals was first developed with local application technology using the light source of 850nm LED locally by Furukawa of a Japanese company approx. 25 years ago. Since then, this system has been installed at overseas LNG terminals and onboard LNG carriers and is still being used. Korean LNG terminals located in Incheon, Pyungtaek, Tongyoung, are also adopting the SSCLS of the Japanese company. Currently, Furukawa is planning to supply their products just to local demands for two coming years due to the problem of procurement of 850nm LED. After that time, it is known that they are going to shift to 1,310nm LD.

LED (Light Emitting Diode) is the technology developed at the early stage of fiber optic communications and usually applied to general industries, not for communications use. As normal LEDs are produced for the wavelength of 400~700nm range, LED of 850nm is classified as special and has complicated manufacturing processes, therefore the LED of 850nm has become old-fashioned and rarely manufactured any longer for the purpose of optic communication systems. However, fortunately, 850nm VCSEL solution that thoroughly compatible with existing 850LED system has been developed by GMB Inc. as a alternative proposal for the LNGC SSCLS. In case of VCSEL, commercial products are available at 850nm as well as 1,310nm and now 1,550nm is under development. In case of 1,310nm LD, data communications are possible for long distances. However, the price of the light source is high. As VCSEL with low threshold current and better characteristics is being made commercial, it is expected to take over the area of LD.

As stated above, the shift to LD will force the LNG terminals and LNG carriers in service to replace with a new SSCLS due to incompatibility of the wavelength. As this shift will be expected to require much money and time, hereafter we are going to compare the kinds, characteristics and technological aspects of various light sources currently available in the market. This comparison will highlight the advantage, economical aspects, and trend of technology when VCSEL is applied.

2 Why 850nm VCSEL for SSCLS

2.1What is a fiber optic communications?

The existing wire or radio communication Unlike the existing telecommunications that uses electrical wire or radio frequency, optical communications can carry light signals through optical fibers.

In order to send information to a location far away, information of words, sentences and pictures should be first converted into electrical signals and the electrical information is again changed into optical signals through an electro-optical converter to be transmitted through optical fiber. When the light information arrives at an electro-optical converter at the other end, the light information is inverted into electrical signals there and sent to the end customer through electrical wire. Then, the customer can restore the information of words, sentences and pictures on an display or other way which were sent from far away.

In short, the transmission between two places far away requires two phases of signal conversion and inversion. See Fig. 1.

In 1960s, the development of semi-conductor laser and the announcement of a paper of "potential capability of massive optical communications through single mode optical fiber" by Dr. Kao, in collaboration with Mr. G.A.Hockham, had initiated the industries to study the manufacturing technology and applications and they got confirmed that the copper wire communications could be replaced with fiber optical communications. The first optic fiber was manufactured by CORNING in 1970 and the laser for optic communications succeeded to

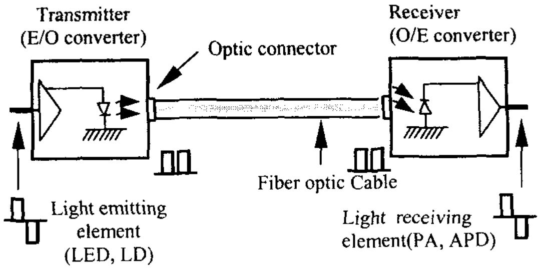


Fig. 1 Schematic Drawing of Fiber optic communication

be oscillated at ambient temperatures which made a history of optic communications. Since then, developments of reliable elements of light source, manufacturing methods of optic fiber, making optic fibers in a form of cable, connection method and measuring method have made the practical optic cables available. Now, long transmission of information is made possible to be sent to distances of 100km to 200km without optical repeaters.

The first generation of optic communications with 800nm was widely used from late 1970s to 1980s.

This optic communications system required repeaters at every 10km. Comparing with coaxial cables, distances between repeaters were much longer in optic communications. So, cost savings could be made with the reduced number of repeaters. This had motivated to use optic communications system by communications system designers.

In 1981, optic communications of super high speed with single mode optic fiber was commercialized and the second generation of optic communications with 1,300nm had started to appear. In 1990, the third generation of optic communications with 2.4Gbps speed successfully started to be commercialized.

Such systems can increase the communications speed with high-performance electro-optic modules and are in the market in Korea. Commercialization of 10Gbps is about to come out in the market soon.

2.2 Electro-optic modules and light source for communications

Electro-optic modules for optic communications equipments are to change the electrical signals into optical signals and vice versa. The demands for them are increasing in overall industries as an essential component. The electro-optic modules are divided into three types. The first is a transmitter which changes the electrical digital signals of voice, picture and data into optic signals. The second is a receiver which inversely changes the received optical signals into electrical signals. The last one is a transmitter-receiver module which combines separate electro-optical converters into one.

Data processing and transmission through electrical signals are susceptible to noises and limited in speed and its accuracy is in doubt sometimes. As a means to resolve such problems, optical signal processing is popular and widely spread.

As electro-optic modules have EMC capability, high speed and high performance, applications are being developed for high-quality equipments. From a standpoint of performance, development of highly integrated circuit solutions are underway for the purpose of high performance, high reliability and compactness.

Fiber-optic transmission/receiving methods are divided into three kinds: Amplitude Shift Keying (ASK) method, Phase Shift Keying (PSK) method and Frequency Shift Keying (FSK) method. For the application of LNG carriers and terminals, FSK of constant amplitude is adopted due to strong resistance to non-linearity.

As light sources of transmission and amplification of data, LED and Edge Emitting LD has been widely used so far. In 1990s, VCSEL is popular as a substitute of the old types.

Currently, LED is used for general industries rather than for communications use. 850nm VCSEL is used for short-distance communications within 1000 meters long and being expanded into the long-distance applications.

VCSEL stands for Vertical Cavity Surface Emitting Laser and as the name suggests. While LD (Laser Diode) horizontally emits light of an oval shape, VCSEL is a very compact semi-conductor laser which emits light in a cylindrical beam vertically from the surface of a fabricated wafer and this makes it possible to have laser chips mass produced, resulting in the drastically reduced cost of packaging. See Table-1 below.

2.3 Fiber Optic Cables

An optical fiber cable is similar to an electrical wire and has properties in common. Both cables are flexible and can carry digital signals. Light travels through a

Table. 1 Comparison between each light source

	LED	LD	VCSEL
Wavelength	450~600 nm	1310 nm 1550 nm	850nm 1310nm
Manufacturing cost	Low	High	Low
Manufacturing process	Difficult	Difficult	Easy
Beam type	edge	edge	Vertical
Optic fiber	Multi mode	Single mode	Multi mode Single mode
Applications	General industries	Long-distance communications	Short-distance comms. and industries

small-diameter glass or clear plastic fiber. Total internal reflection confines the light inside the fiber as it travels a curved path from beginning to end. As in Fig.2 below, the actual fiber composed of three layers. The light actually flows through the central transparent fiber called the core. The core is surrounded by the cladding which is transparent material with an index of refraction (n) lees than the core. The outmost layer is called jacket.

There are two types of standardized optic fibers, one is for single mode and the other for multimode. The major difference between them is the light frequencies supported and the corresponding difference in range. Longer wavelengths running on single mode provide more distance. Multimode fiber cable is constructed with a large-diameter core which allows multiple modes of propagation. Multimode utilizes several wavelengths of light funneled through its fiber core. The core diameter of the multimode fiber is approx. 50 ~ 60μm and can transmit the light sources of LED and VCSEL through it.

Single-mode fiber cable is constructed of a small core and only allows one mode of propagation. Only a single wavelength of light is allowed to pass through the core prevents wavelengths of light from overlapping and distorting data. The core diameter is standardized to be 8.3㎛ and can transmit the light sources of VCSEL and LD.

2.4 SSCLS between LNG carrier and terminals

Emergency Shutdown system, Telephone Interface, Mooring Tension Monitoring system is linked and operated through SSCLS. See Fig.3.

SSCLS consists of a selector module between fiber and electric system, fiber optic PORT/STBD selector module, fiber optic control and alarm module. See Fig. 4.

As in the Table 2 below, SSCLS of LD type does

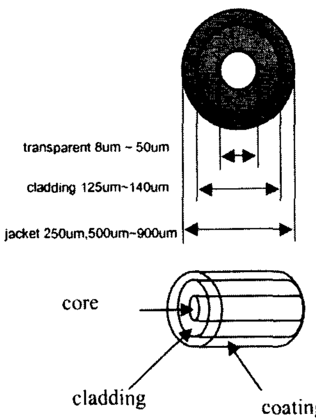


Fig. 2 Structure of Fiber Optic Cable

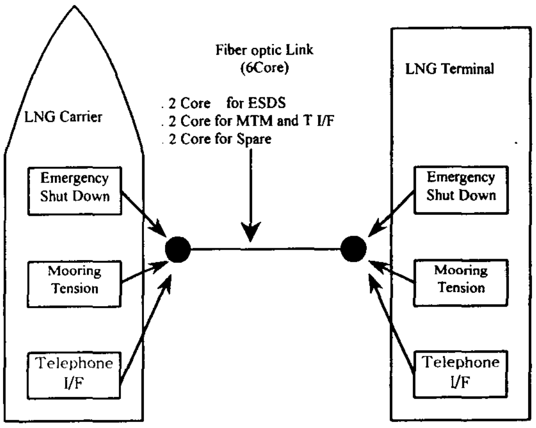


Fig. 3 schematic configuration of Ship/Shore Fiber optic communication

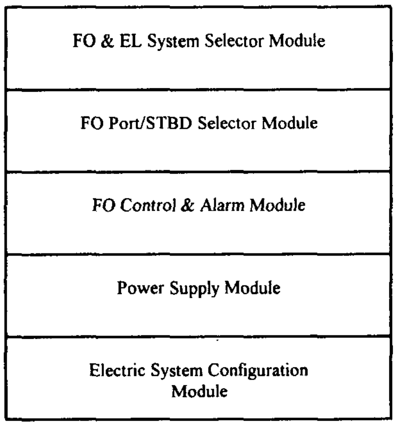


Fig. 4 Panel configuration of SSCLS

Table. 2 Comparison between SSCLS and each light source

	LED type SSCLS	LD type SSCLS	VCSEL type SSCLS
Light Source	LED	LD	VCSEL
Wave length	850nm	1310nm	850nm
Beam type	Edge	Edge	Vertical
	elliptical	elliptical	Symmetrical
Cable mode	Multimode	Single mode	Multi mode
Comm. length	Within 600m	Within 10km	Within 1000m
compatibility	Yes	No	Yes
Product Continuity of Light source Internet	No	Yes	Yes
communication	No	Yes	Yes

not allow for compatibility with the existing system. Also, the shape of light of LD is oval and it needs single mode optical fibers. This means the existing multimode optical fibers can not be utilized as is and they shall be replaced with single mode optical fibers. However, in case of SSCLS of VCSEL type, complete compatibility with the existing system is guaranteed such that no extra hardware is required for the system integrity and this allows for easy maintenance and easy procurement of parts. In addition, 850nm VCSEL that is a light source developed exclusively for communications purpose, gives an extra benefit to the customer that high-speed internet surfing is possible during the period of mooring through the spare optic fibers of the existing fiber optic cable just by adding a simple module.

3 Conclusions

SSCLS had been developed using the light source of 850nm LED 25 years ago. However, in developing an alternative system due to the unavailability of 850nm LED, the compatibility with the existing system and economical aspects can never be overlooked. 850nm VCSEL can be one of the solutions to come up with.

The advantage of 850nm VCSEL is that the wavelength is the same as 850nm LED and the multimode optical fiber can be used and this is suggested that the existing 850 LED system which have been installed for the LNGC and LNG terminal still be available to use continuously subject to apply 850nm VCSEL. This ensures complete compatibility with existing 850nm LED system. As 850nm VCSEL is a module of light source developed for communications use, this can be utilized to communicate through the existing fiber optical cables for high-speed communications without any extra hardware installations.

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