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Development of Portable Control Unit Based on Wireless CATV Tester Unit

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Abstract: In this study, we present the design of the monitoring device used to monitor the status of all optical networks. It begins with the first type developed in direct connection between tapper and display. The second type of wireless technology applied to detect damage to the fiber optic transmitter which is placed on optical line. The status of optical line can be monitored from a distance and do not have a direct connection with tapper. The third type is improved from the second type which is used for multi optical lines. The status of each line can be monitored using only one instrument called a Portable Control Unit (PCU). With this tool built and maintenance work can be done easily and more effectively. The developed solutions are also inexpensive and environmentally friendly. Early damage detection is important to avoid any leakage of the laser in the event of damage (e.g., broken) on active optical lines. Finally, we proposed also the potential application of PCU in small world application such as in-building and in-ship security system to increase the surveillance, cost effective solution and ease of maintenance.

Key words: Portable optical tester, optical fiber monitoring, FTTH monitoring, optical line identifier, fiber optic detection

INTRODUCTION

Fiber-to-the home (FTTH) network system is a broadband network system which can transmit a video, data and voice signals to the number of users. The first serious interest in FTTH began in the late 1980s as the telephone companies gained experience with Integrated Services Digital Network (ISDN) wideband services to subscribers. Today, FTTH has been recognized as the ultimate solution for providing various communications and multimedia services, including carrier-class telephony, high-speed Internet access, digital cable television (CATV) and interactive two-way video-based services to the end users (Lee *et al*., 2006).

To ensure the send signals are in a good condition, a CATV tester device is proposed. The CATV tester device is designed to measure the CATV signals which are passing through the Optical Network Unit (ONU) at the users' premises. A single mode optical fiber signal entering the ONU will be obtained by 'tapping' method and the signal then will be fed into the CATV tester device through optical cable connection. The first generation measuring method for CATV testing system has limited application. For a second generation of the CATV tester device, a wireless technology is applied through the implementation of audio video transmitter and receiver. Then, this tester will display the received signal on the display panel. Although the signal received by the CATV tester device is accompanied by undesired signals and noises, it will then indicate that the status of main FTTH drop line, the possibly damaged and action needed can be easily determined afterwards. By the application of wireless technology, video signal that transmit through the fiber optic cable located in the underground can be easily detected and determined whether it is functioning or not (Ab-Rahman *et al*., 2009c).

Some researchers had discussed about the monitoring issues with OTDR and recommended a number of possible methods to overcome these problems to achieve desired network survivability such as Centralized

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Optical Monitoring using a Raman-assisted OTDR or OTDR-based testing system using reference reflectors or fiber selectors (Caviglia and Biase, 1998). The faulty fiber can be monitored without affecting other in-service channels. However, these methods need relatively expensive additional sources or devices that impose high-maintenance cost. Therefore, improving network reliability performance by adding redundant components and systems have shortcomings in terms of implementation cost and flexibility.

In this study, we proposed low-cost device that can monitor the faulty fiber in Fiber-To-The-Home (FTTH) lines. Fires in manholes, or nearby, often cause cable damage, resulting in loss of service. Accidental digging by construction crews is a frequent problem. These problems can cause customer service interruption. To minimize the problem, wireless-monitoring system in FTTH has been built to monitor and detect the failure in optical line and enable the engineer to make restoration. We use 'tapping' method to obtain the optical signal from FTTH line and the signal then will be fed into the optical passive circuit that consist of WDM Coupler SM 1480/1550 nm and fused coupler SM 10:90 1550 nm.

DESIGN

Device design consists of two levels of Type I and II. The Type II then has been improved to further expand its functions. This section will present the design of the monitoring device which is used to monitor the status of all optical networks. It begins with the Type I developed in direct connection between tapper and display. The Type II is enhanced with wireless technology to detect any damage of optical fiber by means of combined tapper and transmitter which placed on line. Each line can be monitored from a distance and do not have a direct connection with tapper. The third type is improved from the second type (Type II) which purposely for multi-line optical fiber. The status of each line can be monitored using only one instrument called a Portable Control Unit (PCU). With this tool built, the maintenance work can be implemented easily and more effectively. The developed solutions are also inexpensive and environmentally friendly. Detection early is significant to avoid any leakage from the fiber damage (broken). Figure 1 shows the architecture for both types of devices and an increase in Type II and it is important to show the design concept of this new device.

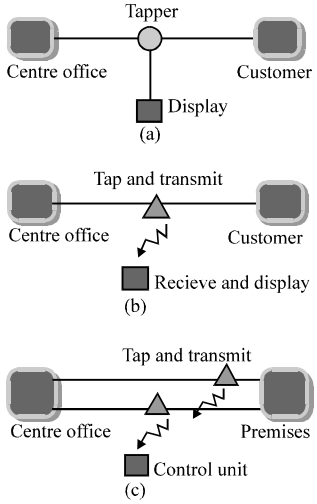

Fig. 1: Architecture of two device types: (a) Type I (b) Type II (c) Enhanced Type II

FIRST GENERATION OF CATV TESTER UNIT

First generation CATV tester unit was developed to measure video signals for FTTH system. The tester consists of two parts; portable unit and passive components. These parts are merged together to form a system that was capable of detecting the video signal for the purpose of displaying its image on television. Signal in the single core optical fiber is obtained through a tapping method and is then connected to the CATV tester unit via an optical wire. CATV tester prototype measures the video signal that is passing through Optical Network Unit (ONU).

The passive circuit functions to split between the data signal and video signal. Data and voice signals have wavelength of 1310 m in which these signals' wavelength differ from the wavelength of video signal, 1550 nm. All of these signals are multiplexed together before being sent to users. Thus video signal needed to be separated from data and voice signals before handed. After the signal is separated, video signal will be sent to fused coupler while the data signal will be sent to WDM coupler. The video signal is separated in accordance to 90:10 ratios. 10% of the signal will be used as a measurement input to the CATV tester unit while the remaining 90% of the signal will be re-multiplexed with the data signal and be sent to users. The video signal will be converted into an electrical signal by signal converter before it is sent and sensed by the display system (Ab-Rahman and Ng, 2009a; Ab-Rahman *et al*., 2009b, c). Figure 2 shows the integration of two parts to form the first generation of CATV tester unit. The signal status can determine

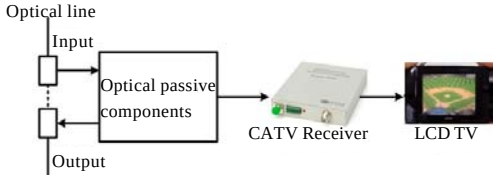

Fig. 2: First generation of CATV tester unit

Fig. 3: The developed CATV tester unit

through the LCD TV. Figure 3 shows the actual prototype of first generation CATV tester unit.

Signal received by first generation CATV tester unit will decide whether the main trunk line is having problems or not. If the received signal by CATV tester unit is in a good condition, it shows that the main trunk line is not having problems and no damages occurred. On the other hands, if the signal received by CATV tester unit consists of interferences (poor condition) it shows that the main cable line is in distress and needed to be fixed. However, this system is difficult to be implemented in closed areas such as underground connection.

SECOND GENERATION OF CATV TESTER UNIT

Video signal transmission system to users via optical fiber has been proven in providing more benefits compared to video signal transmission via satellite. However, the possibility of impairment occur to the network system is unavoidable. Thus, to verify whether impairment has occured, a CATV tester unit is developed. This device used a direct connection to the tapped signal. However, this method limited the area of measurement. Therefore, a new method is developed and introduced where it is possible for the CATV tester unit to detect and measure the video signal without the need of wire connection. With this solution, the receiver will receive signal from the respective tapper without any connection and can be stationed remotely. This innovative solution can be extended to function as a portable and mobile control system to identify the status of CCTV of multiple points. The second generation of CATV Tester is renamed as Wireless CATV Tester Unit (WCTU) (Ab-Rahman *et al*., 2009d).

Signal on the main line will be transmitted to ONU before it is distributed to users. Signals sent to ONU are the already combined signals. Hence, it need to be splitted according to their respective wavelength with 1480 nm for

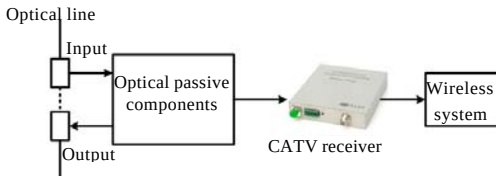

Fig. 4: Second generation CATV tester

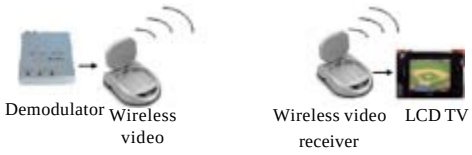

Fig. 5: Transmitter and receiver on wireless

data and voice signal and 1550 nm for video signal by using passive components. In this passive circuit also, video signal will be splitted into a 90:10 ratio. 90% of the splitted signal will be recombined with 1480 nm signal while the other 10% of the splitted video signal will be sent to optical-to-electrical converter to translate the optical signal into an electrical signal (Ab-Rahman *et al*., 2009d).

In the next stage, CATV electrical signal will be sent to wireless system. Wireless system consists of demodulator, A/V transmitter and receiver and portable television. A/V transmitter and receiver operate in transmitting and receiving A/V signal through wireless. To make it easier to understand, the configuration of the system is as shown in Fig. 4. Wireless system configuration can be clearly seen on Fig. 5. This system is made of two parts; transmitter and receiver. Remaining 10% of video signal will be fed to CATV tester unit to be measured. CATV optical receiver will convert 10% of the optical video signal into analog radio frequency signal. This radio frequency signal will next be translated into A/V signal using demodulator. After the audio/video signal is successfully obtained, the signal will be fed to transmitter for it to transmit the signal to receiver.

As the final step, the received signals obtained by receiver will be displayed on portable television. Similar to first generation, second generation CATV tester unit will determine the state of the signal based on the received channel displayed image. Briefly, the overall system configuration for second generation CATV tester unit is shown in Fig. 6.

This FTTH network will be tested using components and equipments such as optical fiber (WDM 1480/1550 nm and TWC 1550 nm 10:90) WSG coupler

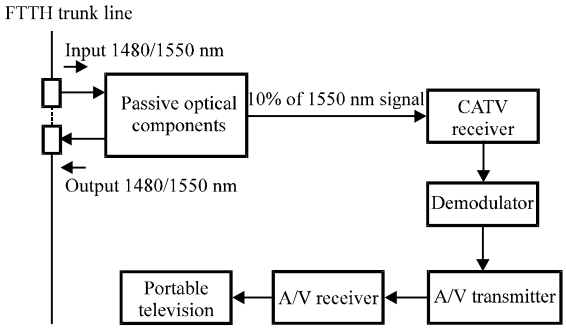

Fig. 6: Second generation CATV tester unit block diagram

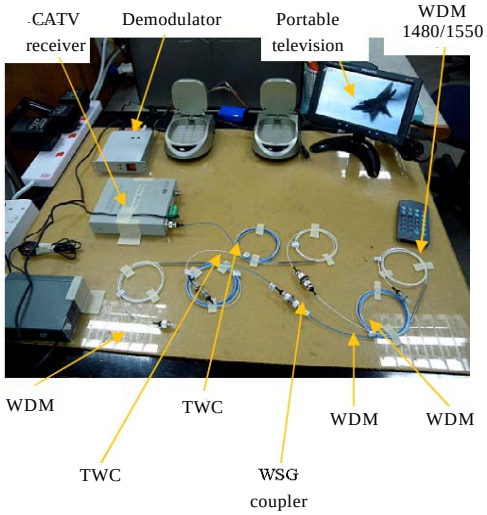

Fig. 7: Overall system of second generation CATV tester unit

connector, CATV receiver, demodulator, A/V transmitter and portable television. Components involved in CATV tester on FTTH network are as shown in Fig. 7.

From the testing carried out, specifications of measurement device can be determined. Second generation CATV tester operates on 12V (d.c) and is capable of measuring CATV video signal with frequency in the range of 40MHz-870MHz.This CATV tester is capable of detection via wireless for a maximum distance of 30 m.

APPLICATION: IN-BUILDING SECURITY SYSTEM

WCTU also can be enhanced to serve as the PCU where the detection unit is connected to the master unit receiver. By adjusting the appropriate frequency, the signal will be sent from a specific detection unit to the master unit receiver. Very wide application is in-building

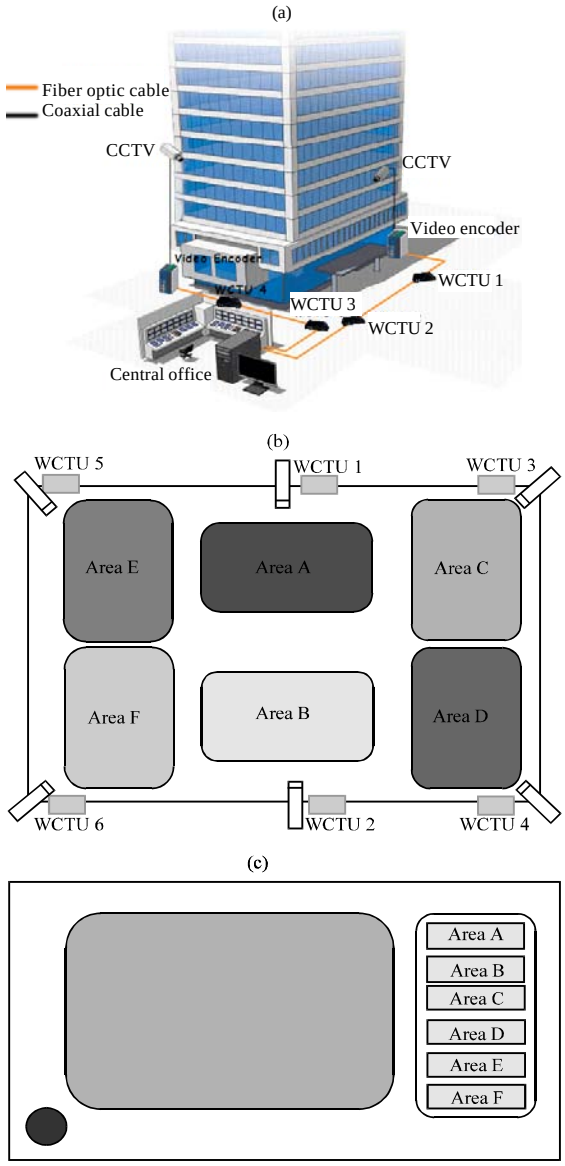

Fig. 8: (a) WCTU increases the surveillance of the in-building application, (b) Installation in the building schematic and (c) portable control unit to monitor each WCTU

security system where every corner is fitted with the detection unit. The status of each area will be monitored by adjusting specific frequencies. With this building security guards able to monitor every corner of the building and can move easily without the need for the system control unit which is usually static. Applications can be shown clearly in Fig. 8.

Another proposal of this system has been suggested to implement in a ship (navy ship) as shown in Fig. 9.

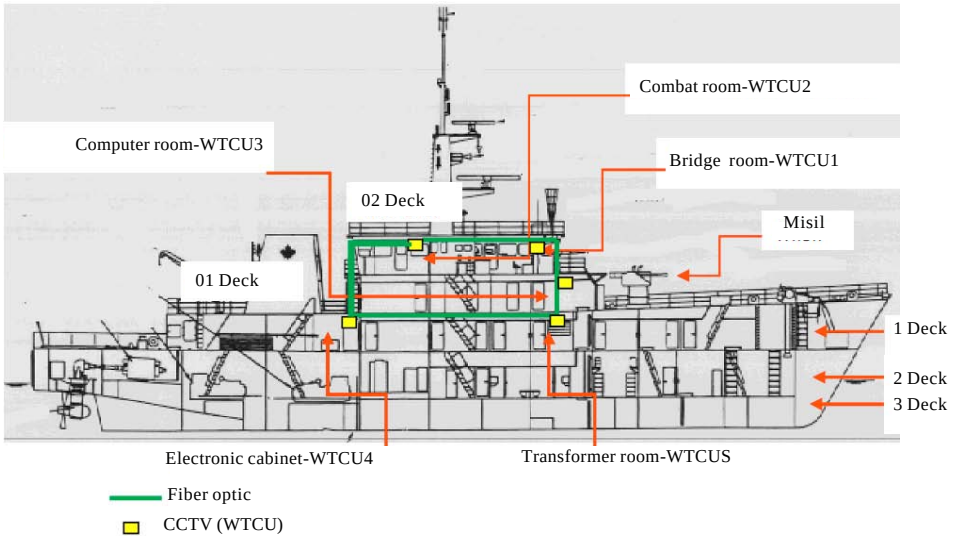

Fig. 9: WCTU increase the surveillance of the ship (navy ship) application

There have 5 rooms need to be installed this CCTV Mobile Control Unit in order to monitor the activities on the ship and to maintain the security. In the Bridge Room it used to navigate the ship and there have a PC to monitor all of these CCTV. Second CCTV is suggested to install in the Combat Room that used to control and fire the misile. Next, this system is applied in the Computer Room and Electronic Cabinet Room that control all the operation in this ship. Last application is in the Transformer Room that supply the power to the misil. All of these rooms need to be monitored by this CCTV system because only certain people are allowed to enter and operate the equipments in these rooms. This system will be connected with fiber optic and it can be control by Portable Control Unit.

CONCLUSION

The system design and development of second generation CATV tester unit via wireless method is developed and applied on the FTTH system network. The development of CATV tester unit is in correspond of the latest technology development considering the widen usage of optical fiber as transmission medium. With the usage of CATV tester unit, it brings ease in testing and maintenance works of verifying damages reported by users. Therefore, CATV tester unit satisfies the market demands and posses commercial qualities. Surveillance is an important part of every business even a small lapse may cause dangerous situations. Video surveillance and remote monitoring can be considered as an enhanced management tool that can be effectively used by various departments of an organization. This integrated system design will introduced a portable, mobile, wireless hand-held control unit from which a viewer can monitor CCTV cameras and control cameras in real time.

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