AQ7260 SERIES OF NEW OTDRS FOR FIBER-OPTIC INSTALLATION AND MAINTENANCE

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The Optical Time Domain Reflectometer (OTDR) is an instrument capable of detecting and measuring fiber-optic break points or splice points, as well as distance-related data, in fiber-optic communication networks. In line with the recent spread of "Fiber to the Home" (FTTH) technology, there is a growing need to detect these break and splice points in short-distance networks with even greater accuracy. In order to meet this need, we have developed OTDRs with a maximum distance resolution of 5 cm. Furthermore, as a new measurement application we will introduce live-line measurement technology using a 1650-nm wavelength, different from the 1310/1550-nm working wavelengths used for communication lines.

INTRODUCTION

Fiber-optic communication systems, developed as communications have grown in capacity, have evolved into the "Fiber to the Home" (FTTH) technology whereby optical fibers have been connected to households in every country including Japan since the beginning of the new millennium. Due to this evolution, the test features required in fiber-optic installation have also changed.

At the time fiber-optic networks are installed for trunk lines connecting large cities, the Optical Time Domain Reflectometer (OTDR) must have a high dynamic range since long-distance optical fibers are measured during installation. In contrast, when measuring short-distance fiber-optic networks such as FTTH, high distance resolution is needed to measure locations such as break points more accurately. Also, in conventional fiber-optic measurements using an OTDR, measurements were made using the same wavelength range as the working wavelength (such as 1310/1550 nm) used for communications. However, measurement demands at a wavelength range (such as 1650 nm) that has little effect on transmitters have also been increasing because of the necessity for live-line measurements in fiber-optic networks that have been operating. To meet these market requirements, we have developed the new AQ7260-series OTDR. Figure 1 shows the external view of the AQ7260 OTDR.

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OTDR

Figure 2 shows the principles of the OTDR.

The OTDR is an instrument that measures fiber-optic splice losses and return losses or the distances to such splice or break points. It achieves these by launching pulse light into the fiber-optic network to be measured and measuring minute reflected light that returns to the incident end depending on that pulse light, in time domain.

Figure 1 External View of AQ7260 OTDR

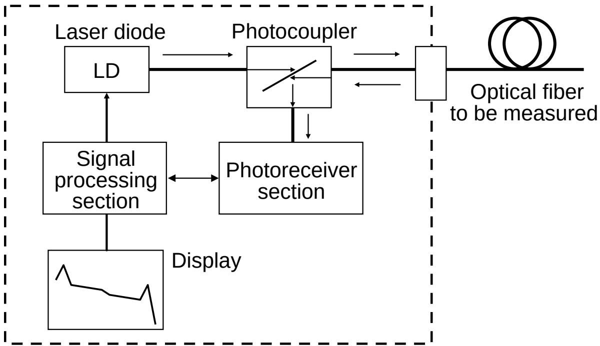

Figure 2 Principles of the OTDR

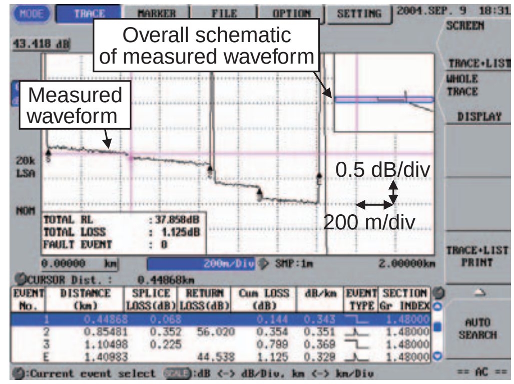

Figure 4 Example of Measurement Using the OTDR

CONFIGURATION AND FUNCTIONS OF THE AQ7260 OTDR

AQ7260 OTDR Measurement Principle

This section describes the OTDR measurement principle on the basis of the AQ7260 functional block diagram in Figure 3.

In the diagram, the laser diode (LD) emits light under operation of pulses generated by the pulse generator (PG). This pulse light passes through the photocoupler and enters into the optical fiber subject to measurement.

In the optical fiber, Rayleigh scattering occurs and some of the scattered light (back scattered light) goes opposite to the traveling direction of the pulse light and returns to the OTDR. Moreover, Fresnel reflection light generated at splice points also returns to the OTDR.

These return lights (hereafter referred to as “reflected light”) are again passed through the optical coupler and are converted from optical signals into electrical signals by a photoreceptor device. They are then sampled by the A/D converter at a timing synchronized with pulse generation. The power of reflected light in the optical fiber can be understood from this A/D-converted amplitude data, and the location of reflected light in the optical fiber can be known from the time between the instant the pulse light is emitted and the instant its reflected light returns. In this way, the OTDR can measure the power of reflected light at each location in the optical fiber and calculate losses between any two points from the difference between the power levels.

Since the signal level of the reflected light is very low, measurement is repeated a number of times to obtain the average of measured values at the averaging circuit in the diagram. This facilitates noise reduction.

Figure 4 shows an example of an actual waveform measured using the OTDR. The vertical axis represents the power of the reflected light, while the horizontal axis denotes the distance.

Technology of Migration to a High Distance Resolution

This section describes a method for improving sampling resolution on the distance axis.

As described above, the OTDR measures the distance of an optical fiber by synchronizing sampling with pulse generation. Therefore, to measure the locations of fiber-optic breaking points with greater accuracy, the reflected light must be measured at a higher sampling time period.

To realize the sampling resolution of an optical fiber length of 5 cm, an A/D converter capable of sampling at 2 GHz is needed. However, there are no high-speed A/D converters which solve a shortage of the number of transmission bits or meet linearity performance, etc. Moreover, use of an ultrahigh-speed A/D converter is also disadvantageous from the viewpoint of battery-driven operation.

Thus, as shown in Figure 5, the AQ7260 OTDR performs measurements shifting the timing from light emission by the LD with the A/D converter sampling periods kept constant, and then

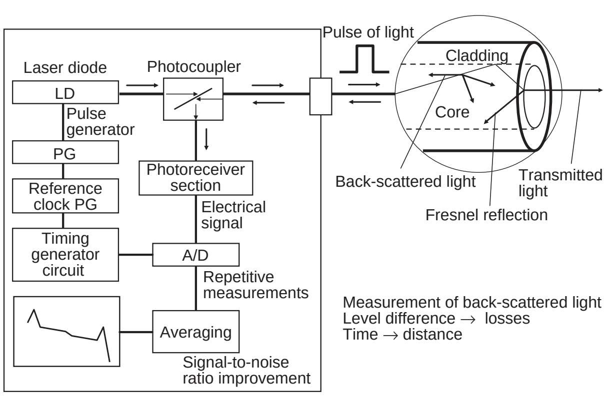

Figure 3 AQ7260 Functional Block Diagram

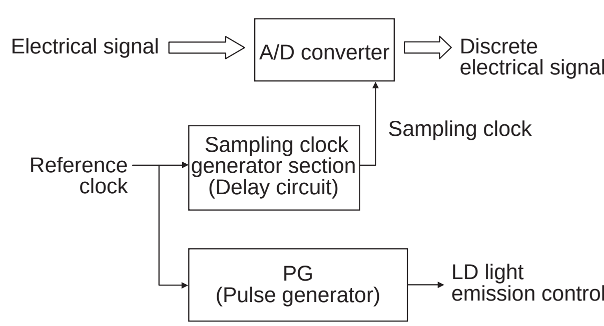

Figure 5 A/D Sampling’s Timing Generator Circuit

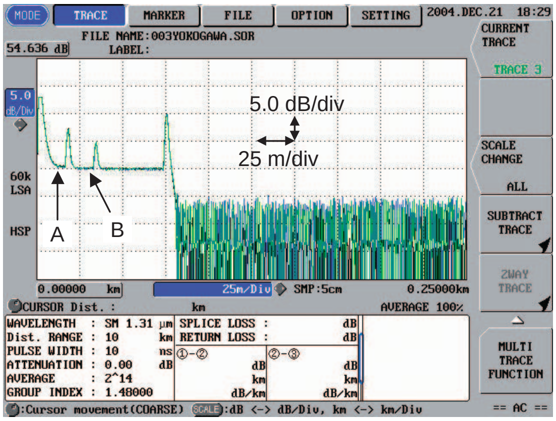

Figure 6 Example of Measurement at 5-cm Resolution

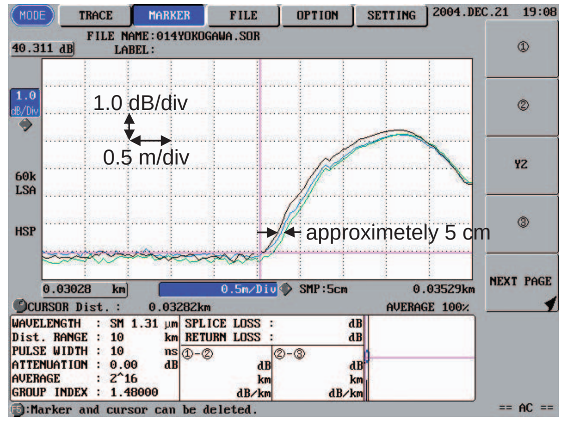

Figure 7 Enlarged View of an Area at Point B

synthesizes the measured signals. This allows them to achieve a maximum distance resolution of 5 cm, equivalent to a sampling rate several ten times the reference clock.

The AQ7260 OTDR automatically determines the distance resolution from the number of measured data and the measurement range. Figure 6 shows an example of measurements at a distance resolution of 5 cm. This figure represents the data measured and overlaid by shortening the optical fiber length between points A and B to 10 cm and 5 cm in a system that connects approximately 15 meters of fiber (up to point A), approximately 17 meters of fiber (between A and B), and approximately 43 meters of fiber (point B and after).

Figure 7 shows the enlarged waveform of an area close to point B. One can observe that the splice point at point B was shifted by 5 cm because the optical fiber was made shorter in increments of 5 cm.

Example of Measurement at Non-communicable Wavelength

A system called “Passive Optical Network” (PON) is introduced into many of fiber-optic networks closer to the users (subscribers), such as FTTH.

Figure 8 shows the overview of a general PON system. Here, we consider the case of measuring the optical fiber from the branch (optical splitter) in the PON to new subscriber C that is made for the subscriber C, assuming that services (communication) have already been provided for subscribers A and B.

In this case, there is a possibility of adversely affecting communication services if the OTDR emits a pulse light having the same wavelength as the 1310-nm or 1550-nm working wavelength used for communication services. Thus, Yokogawa offers the plug-in optical module capable of making measurements at the 1650-nm wavelength.

The optical sources of transmitters or communication-measuring instruments use a component know as a laser diode (LD). This component does not have a complete, single spectrum width with little effect on the transmitter using a communication wavelength, but does not excessively narrow the spectrum width causing disturbance in OTDR waveform due to the effects of interference.

Figure 9 shows OTDR waveform obtained using a light source with a narrow spectrum width such as a distributed feedback laser diode (DFB-LD) and OTDR waveform obtained using the currently adopted LD. It is evident that the noise width, which was approx. 1 dBp-p in the case of the DFB-LB, has been improved to 0.2 dBp-p.

FEATURES

OTDRs allow analysis of the distribution of losses in an entire optical fiber or the locations of splice and breaking points by measuring the single-end of the optical fiber; they are used for the installation of optical fibers or maintenance of already-installed optical fibers.

Compact, Lightweight, and Long-driven by Battery

Because the OTDR is also used for the installation of optical fibers prior to the installation of transmitters, it is must be driven by battery for many hours so that fiber-optic installation using it can be carried out in locations without a power supply. At the same time, portability and lightness also become important factors for the OTDR.

To meet these needs, the AQ7260 OTDR has achieved 6-hour battery-driven operation and a weight of only 3 kg.

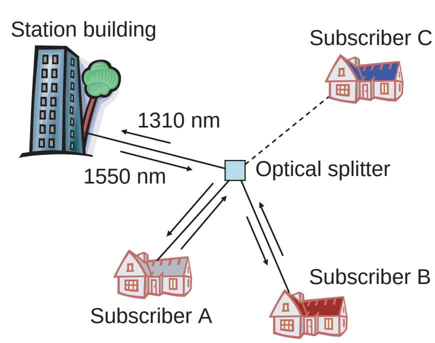

Figure 8 Overview of the PON System

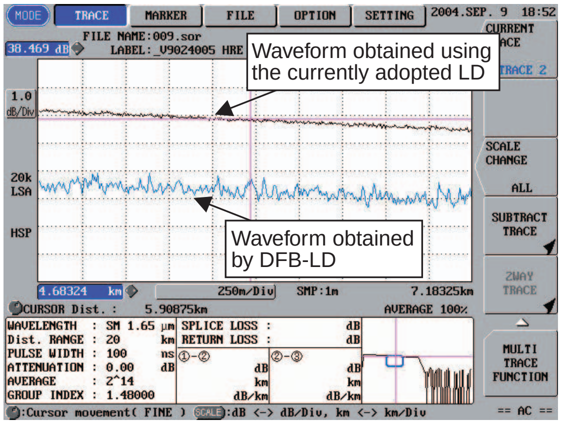

Figure 9 Comparison of OTDR Waveforms between Currently Adopted LD and DFB-LD

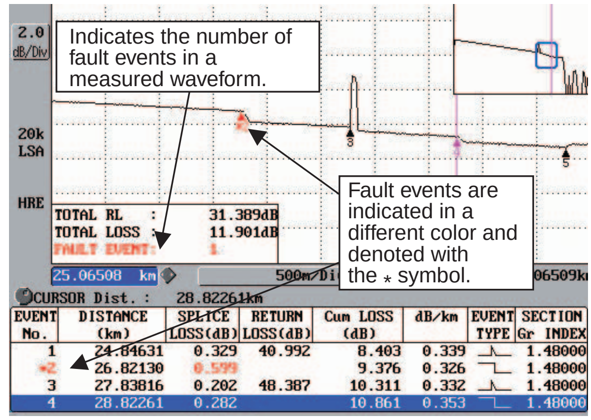

Figure 10 Example of Fault Event Display

Short Dead Zone

The dead zone is a specification indicating the capacity of identifying splices to short-distance optical fibers. The AQ7260 ODTR has achieved an event dead zone of 2 m (typical) and an attenuation dead zone of 7 m (typical). These allow measurements of fiber-optic splice points and losses in stations and enclosures.

Improved Viewability

The AQ7260 OTDR has employed a large color TFT-LCD with a wide viewing angle so that a sufficient field of view is secured to make operations easier.

Automatic Measuring Conditions Setup and Automatic Splice Point Detection

We have improved the automatic measuring conditions setup function and automatic splice-point detection function because the number of users who use the OTDR for the first time is on the increase as the demand for work such as FTTH increases.

The automatic measuring conditions setup function is a function in which the OTDR determines the length of the optical fiber subject to measurement to automatically select the optimum measuring conditions for measurements. For the automatic splice-point detection function, we have enhanced the algorithm to improve the splice and breaking point detection accuracy. These functions allow a reduction in the number of operations relating to splice point detection in the measurement field, improving work efficiency. Moreover, we also improved the measurement result display method so that points (fault events) at which a loss value or return loss exceeded a specified value can be easily identified on a measurement result list. This enables the user to determine pass/fail in the field more easily. Figure 10 shows an example of the measurement results with a fault event present.

Multi-lingual Capacity

Fiber-optic communication systems have been widely used by communication carriers in many countries, and OTDRs have also been used worldwide. Thus, OTDRs support many languages such as English, Chinese, German, Italian, Korean, and so on in addition to Japanese.

Extension of Storage Media and Report Creation Function

For the media in which OTDR measured results can be saved, OTDRs support the internal memory (20 MB) and USB memory in addition to FD (optional) and PCMCIA, which were also available in conventional models. Data saved in these memories can be analyzed on a PC using the newly developed AQ7932 OTDR emulation software. Moreover, use of this software's Create Report wizard allows you to easily prepare work reports during the installation of optical fibers.

Enhancement of Product Lineup

We provide a wide range of products: the AQ7261 priced reasonably to meet user needs, the AQ7264 for general-purpose use, the AQ7265 with a high dynamic range that can be used for evaluation of long-distance optical fibers, and the AQ7267 compatible with the 1650-nm wavelength.

CONCLUSION

In this paper we have described migration to high distance resolution for detecting fiber-optic slice and breaking points with even greater accuracy and the live-line measurement method that has minimal effect on transmitters. The requirements of OTDRs are being diversified as communication systems evolve. We wish to pursue product development promptly to meet newly emerging market demands from now on. ◆

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