Development of the AQ7280 High-performance OTDR and its New Features

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Yokogawa has newly developed the AQ7280 high-performance optical time domain reflectometer (OTDR) as a successor to the AQ7275. This previous model and AQ1200 have been popular for measuring optical fiber networks during their installation and maintenance because they cover a wide range of optical networks, from a fiber to the home (FTTH) network to a core network.

While inheriting the excellent functions of the previous model, the AQ7280 comes with new features. In addition, its new optical module and improved electric circuit configuration have achieved a high dynamic range and a short dead zone.

This paper describes this new optical module and the internal electric circuit technology that have achieved the high performance, and introduces the new features of the AQ7280.

INTRODUCTION

As smartphones are becoming increasingly popular and cloud services are spreading rapidly, quality control of optical fiber networks supporting the increasing communication traffic is regarded as more important than ever. For installation and maintenance of optical fiber networks, measuring instruments are required to offer high accuracy, high resolution, and flexible responses to requirements of various tests.

Meanwhile, due to increasing numbers of unskilled engineers working at sites, problems are developing in which configurations of complex networks are not being understood easily by these site workers. Subsequently, working efficiency at affected sites must be improved.

To respond to such market needs, Yokogawa released the AQ7280 OTDR, which is a high-performance model with a high dynamic range of measurable optical intensity and short event dead zone. In addition, its newly added functions enable improvements in working efficiency to be made at sites without relying on workers' skills. Figure 1 shows the external view of the AQ7280.

Figure 1 External view of the AQ7280

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SYSTEM CONFIGURATION

Figure 2 is the block diagram showing the system configuration of the AQ7280.

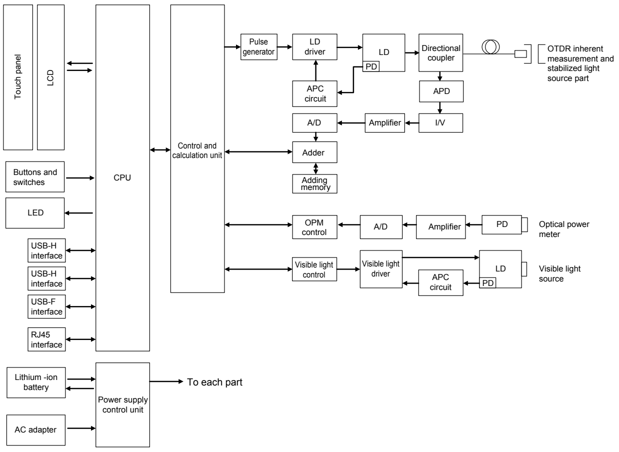

Figure 2 Block diagram of the AQ7280 system configuration

To achieve a high dynamic range and short event dead zone, a new optical module has been adopted, and the electronic circuit has been modified. In addition, a new smart mapper function for improving working efficiency, and touchscreen operation for improved user experience have been incorporated. This paper introduces the performance improvements and advanced functions of the AQ7280.

TECHNOLOGIES SUPPORTING HIGH PERFORMANCE

New Optical Module

An OTDR inputs a pulse emission, generated by a laser diode (LD), into the optical fiber to be measured through a directional coupler. Fresnel reflection light and backscattered light are detected by an avalanche photodiode (APD) and converted into electrical signals. Signal processing is performed on them, and the results are displayed in waveforms on a LCD or other devices. In this configuration, the key devices are bi-directional optical modules composed of a LD, directional coupler, APD, and other devices.

The AQ7280 is equipped with a high power bi-directional optical module and high receiving sensitivity as compared with the previous model, to achieve a high dynamic range of 50 dB. As for the optical system, the bi-directional (BiDi) method is used as with the previous mode [(1)].

Previously, a half mirror was used to couple lights from a LD to a fiber and from a fiber to an APD. However, a half mirror causes a loss in light intensity of 3 dB in both directions. As a result, it cannot generate high power or sensitivity.

The new optical module uses an optical circulator, a polarization independent isolator, for the directional coupler. The insertion loss of an optical circulator is lower than that of a half mirror. Figure 3 shows the optical system of the new optical module.

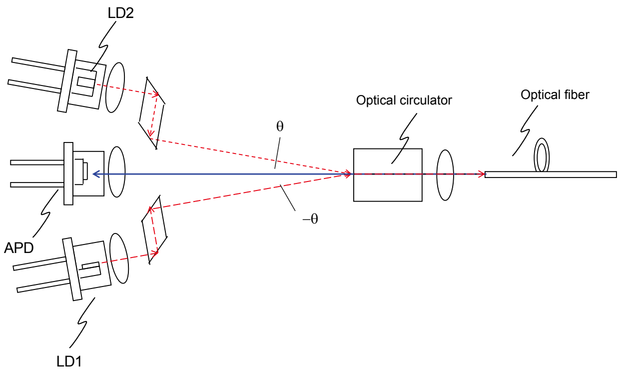

Figure 3 Optical system of the optical module

From the transmission side, the light pulses from the LD1 are polarized in a primary wave, go through the optical circulator, and enter the optical fiber. Likewise, the light pulses from the LD2 are polarized in a secondary wave, go through the optical circulator, and enter the optical fiber. The insertion loss of the optical circulator is as low as approximately 0.3 dB, which ensures it achieves high power compared with the previous model.

Meanwhile, on the receiver side, the light from the optical fiber enters the APD through the optical circulator. The insertion loss of the optical circulator is as low as approximately 0.3 dB as with the case of the transmitter, which ensures it achieves higher sensitivity compared with the previous model.

Measurement by OTDRs usually supports multiple wavelengths per individual port. Applying the scheme shown in Figure 3 to this model, LD outputs of different wavelength are multiplexed by a wavelength division multiplex (WDM) filter to achieve up to four wavelengths per individual port.

Figure 4 shows the external view of the optical module for this model with a high dynamic range of 50 dB.

Figure 4 External view of the optical module

To achieve high power, two LDs of 1310 nm and two LDs of 1550 nm are used, and their outputs are multiplexed through the polarization synthesis. The dimension of the case for the optical module is 23.5 mm × 44.5 mm × 10.5 mm, for which the footprint is reduced by 87% compared with the usual design in which optical fiber couplers are used. By using this optical system, optical reflection within the module is suppressed, and the overall return loss becomes 40 dB or higher, which contributes to a reduction in the secondary reflection in the OTDR. In addition, yttrium aluminum garnet (YAG) laser welding is used to bond all important points. The improvement in bonding strength due to a joining process utilizing metal ensures long-term reliability.

Performance Achieved

The dynamic range performance is expected to be improved due to the higher output power of the optical pulse in the transmitter part, the higher gain of the amplifier in the receiver part, and other means.

In the transmitter part, the high current output of the LD driver is increased to create a high power optical pulse, and its electronic circuit is configured so that the peak value does not decrease even during narrow optical pulse operation. For simultaneous emissions from two LDs, the timing of emission is tuned to be optimal in order to suppress waveform distortion.

In the receiver part, the gain of the amplifier circuit has been increased to improve receiving sensitivity, which expands the dynamic range. In addition, the amplifier circuit composition has been tuned to avoid the saturation of the receiving circuit caused by the high sensitivity of the optical module and the high power of the transmitter part described above. As a result, the dynamic range of 50 dB has been achieved as shown in Figure 5.

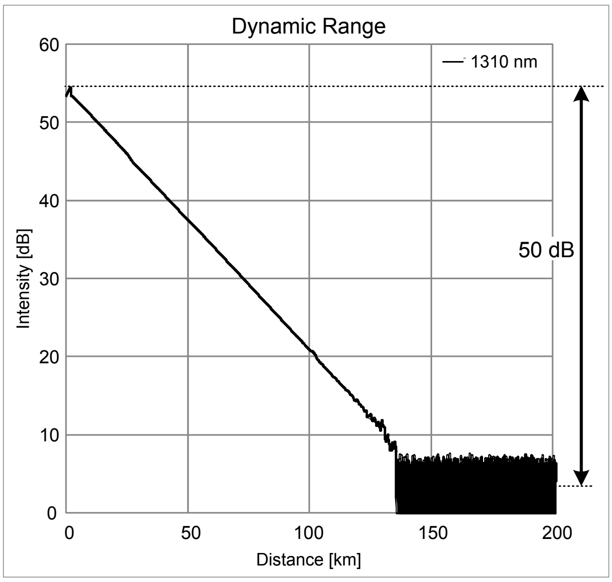

Figure 5 Dynamic range evaluation results

The performance for a dead zone is determined by the waveform quality of narrow optical pulses emitted from the transmitter part, and the responsive performance of the receiver part.

In the transmitter part, the responsiveness of the LD driver circuit has been improved so that the pulse width during emission of narrow optical pulses becomes a prescribed width. This circuit causes less waveform distortion.

In the receiver part, the frequency bandwidth for receiving signals has been broadened to improve the responsive performance when receiving narrow optical pulses. In addition, in order to suppress waveform distortion such as ringing that arising when bandwidth is broadened, the transient response characteristics of the receiver part has been optimized. As a result, the event dead zone of 50 cm has been achieved as shown in Figure 6.

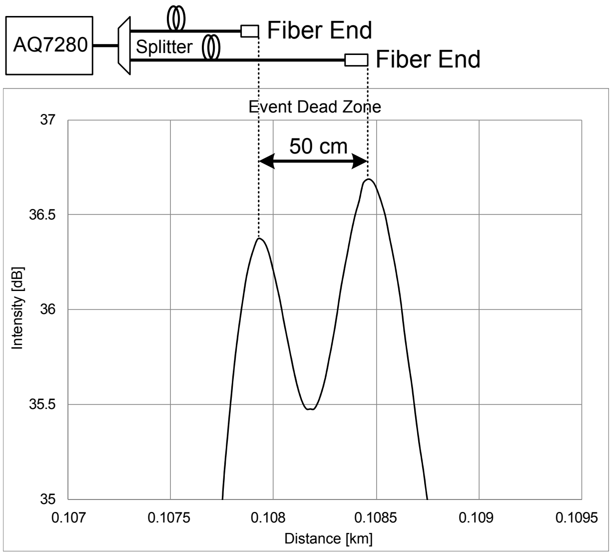

Figure 6 Event dead zone evaluation results

ADVANCED FUNCTIONS

Smart Mapper Function

The smart mapper displays complex network configurations to be measured as a map view in an easy-to-understand manner, as shown in Figure 7.

This function takes several measurements under different conditions with a single operation, and produces a combined display of all the results of each measurement. Thus, all the events can be clearly identified. Threshold values for judging whether or not observed results are regarded as an event are set in advance.

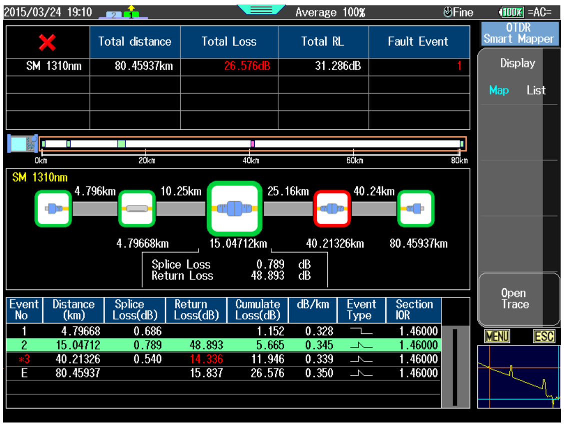

Figure 7 Smart mapper main screen (map view)

The measuring results that are used for the map view can also be displayed in waveform as a waveform view, as shown in Figure 8. Because displaying all the waveform data on the same screen is complicated, only the data in the areas regarded as effective by the analysis are combined and displayed. In the waveform view screen, the combining point of each waveform can be shifted, and the information relating to each event can be edited.

Figure 8 Smart mapper waveform view screen

Figure 9 shows the data processing sequence for the smart mapper.

First, multiple pulse widths of data that requires analysis are chosen based on the route configuration, and then data processing for each pulse width is performed sequentially. After data processing of each pulse width has been completed, all waveform data are analyzed in order to determine effective regions within them. Event analysis processing is performed using the data in the effective region of each waveform, and the results are combined. Finally, the event analysis results are displayed in map view.

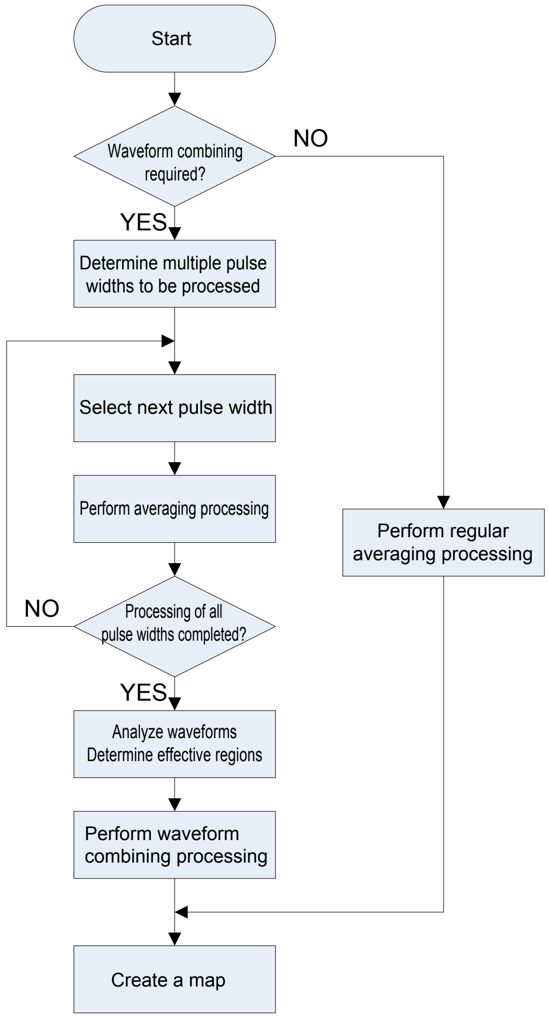

Figure 9 Data processing sequence for the smart mapper

Use of the smart mapper provides the following benefits:

- Measurement by simple settings with fewer misoperations
- Obtaining measuring results suitable for distances to the ends of measured route, regardless of connection or end point
- Display in a map form that is easy for unskilled engineers to understand

Improved User Experience by Touch Operation

As smartphones are becoming popular, users' demand for touch operations, even for OTDRs, industrial devices, is increasing. Because the number of unskilled engineers being utilized is increasing as described above, there is an increasing need for OTDRs to offer intuitive touch-based operations.

The AQ7280 has achieved the following operations thanks to the use of a capacitive touchscreen.

■ Direct Access to Desired Functions

With the AQ7280, a single touchscreen operation can navigate an operator to the screen of a desired function, while several operations were required in the previous models, as shown in Figure 10.

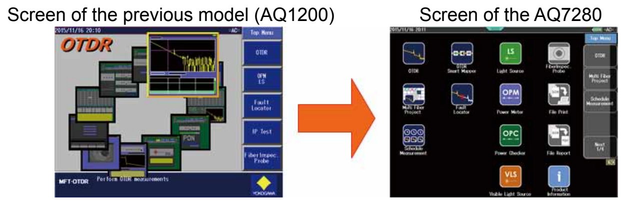

Figure 10 Comparison of operations on top screens

Function selection procedures on the top screen for the previous model AQ1200 and the new model AQ7280 are as follows.
Previous model AQ1200:
(1) Select a function by using a rotary knob.
(2) Press ENTER to execute the selection.
New model AQ7280:
(1) Touch a function on the touchscreen.
In addition, as shown in Figure 11, the areas in which measuring conditions are displayed, although they were only used for display on the previous model, are set as touch areas to open corresponding menu windows for selecting measuring conditions, eliminating the extra operations required to open the menu window.

Figure 11 Example of touch operation on an area displaying measuring conditions

■ Response Areas on Touch Operation
In designing touch operation, the widths and heights of touch areas have been set wider than those of the previous model to prevent misoperations. For example, as shown in Figure 12, the line spacing in the measuring results display for the AQ7280 has been enlarged to approximately 6 mm for easy touch operation, while that of the previous models AQ1200/AQ7275 was approximately 3.7 mm. By the way, the line spacing in usual smartphones is approximately 7 mm.

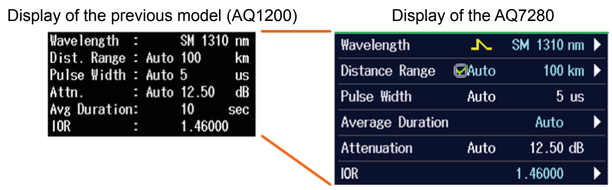

Figure 12 Comparison of the line spacing in measuring results display

In addition, to make an operation for selecting small icons smooth, the touch areas for them have been set to be sufficiently wide, irrespective of icon sizes. Figure 13 shows one such example.

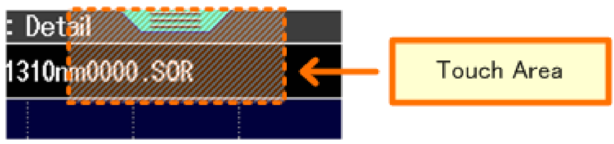

Figure 13 Touch area for a small icon

■ Zoom Operation
When analyzing a waveform, waveform scaling that only occurs in the direction of the distance or optical intensity axis is beneficial. To achieve this, the AQ7280 offers an operation that zooms in or out in only the vertical or horizontal directions, instead of the usual zooming in/out operation that keeps an aspect ratio constant, as shown in Figure 14.

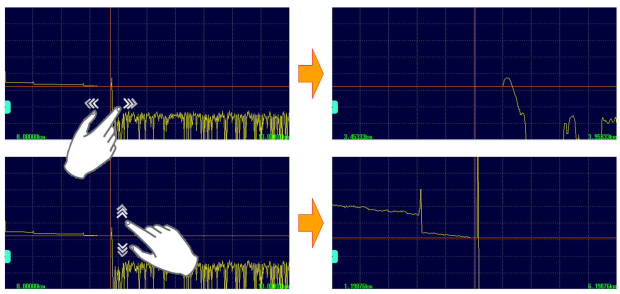

Figure 14 Zooming-in operation in the waveform area

■ Execution of Multiple Tasks
In order to measure several fibers serially, several tasks, as listed below, are required for each fiber core.
(1) Inspection of the fiber surface (fiber inspection probe)
(2) Optical power measurement (OPM)
(3) OTDR measurement
Measuring carried out by an OTDR takes a certain amount of time. Therefore, performing another task for another fiber core in parallel with the inherent measurement can improve overall working efficiency. To achieve this, the AQ7280 comes equipped with a mechanism to carry out parallel processing of multiple tasks, in which an

application function can be started during the inherent measurement, as shown in Figure 15.

Figure 15 Example of multiple tasks executed in parallel

By using the above-mentioned function, users can obtain the following benefits.

- Elimination of extra operations such as those required to start each application function via the top screen
- Parallel execution of tasks for several fibers

CONCLUSION

This paper described the development and new functions of the AQ7280 high-performance OTDR. The AQ7280 offers a high dynamic range and short dead zone, both of which have been achieved with a new optical module and optimized electronic circuit. Thanks to the use of a capacitive touchscreen, smart mapper function, and other features, now even unskilled engineers can easily operate the AQ7280.

Yokogawa expects that the AQ7280 contributes to the expansion of optical communication networks.

REFERENCES

(1) Hiromi Yoshida, Yoshihito Tekawa, et al., “Development of High-performance, Multifunctional Compact OTDR,” Yokogawa Technical Report English Edition, Vol. 55, No. 1, 2012, pp. 19-22