Development of MT9083 ACCESS Master Fiber Visualizer and Connector Inspection Functions
—Dramatic Simplification of Field Work—

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[Summary] More optical fiber cables have been installed to support high network capacity in mobile backhaul. Although the OTDR is a useful tool for installing and maintaining optical fiber cable networks, it is desirable to simplify OTDR field testing for more inexperienced OTDR users. Hence, we have developed the Fiber Visualizer as an enhancement to the MT9083 ACCESS Master. The Fiber Visualizer has the advantage of optical fiber cable testing using automated icon-based Pass/Fail analysis. In addition, we have produced a new optical connector inspection function to detect troublesome damage to the connector tip end face. It automates inspection based on IEC61300-3-35 to improve field work efficiency.

1 Introduction

The rapid spread of smartphones increases the mobile data traffic volume due to more frequent download of large-size files, such as video[1]. To support an increase in volume of mobile data traffic, coaxial cables which is installed between Base Band Unit (BBU) and Remote Radio Head (RRH) are replaced with the optical fiber cables[2, 3].

The optical fiber cables have the ability of high capacity data transmission in comparison with the coaxial cables. However, the strong bend and tension of optical fiber cables are easily damaged and could make large optical loss. Since optical fiber cables are less robust than coaxial cables, careful treatment is needed in comparison with the coaxial cables. Recenltly, field engineers who does not have experience in handling the optical fiber cables have to treat optical fiber cables because that the coaxial cables are replacing to optical fiber cables due to high data capacity demands. Hence an easy-to-use optical fiber tester is required to support their work.

For this requirement, we have developed the all new easy-to-use the optical fiber test function, that is called Fiber Visualizer for the MT9083 ACCESS Master. Fiber Visualizer displays easy-to-understand graphical icons of optical fiber conditions and events (fiber bends and connectors) with simple Pass/Fail evaluations. The Fiber Visualizer does not require that the field engineer analyzes the cable condition from the measured OTDR trace. Therefore, the field engineers with no experience of optical fiber cables can easily check and evaluate the optical fiber cables. Figure 1 shows the external view of the MT9083 ACCESS Master.

Figure 1 External View of MT9083 ACCESS Master

In case the optical connector on the fiber end is dirty or scratch, it causes the large back reflection or large losses. A single-mode fiber (SMF) consists of an core with a diameter of 10 μm surrounded by cladding (125 μm diameter). The slight dirt and scratch mated into the core prevents the optical signal from propagating to the fiber, it could lead to the transmission failure. Since the core diameter is only 10 μm and the particle of the dirt is smaller than the diameter of the core, field engineers require microscope to check dirt and scratch on the surface of the optical connector. For the easy inspection of the optical connector, we have also developed the new optical connector inspection function for the MT9083 series.

This article describes the configuration and main functions of the MT9803 ACCESS MASTER in section 2, the development of the Fiber Visualizer function in section 3, and the optical connector inspection function in section 4.

2 MT9083 Series Access Master

2.1 Basic Configuration

The MT9083 series is the overseas version of the Anritsu ACCESS Master. The series is the all-in-one and compact tester, which has OTDR functions, an optical power meter, stabilized light source, and visible light source. The series offer various models with different dynamic ranges, supported wavelengths, installed optical power meter, etc., for various applications.

When compared with previous models[4)], the present OTDR introduces high-performance optical parts and the optical receiver circuits with a better S/N ratio. As a result, the MT9083C2 model achieves the maximum dynamic range of 46 dB while maintaining a world class short dead zone of 0.8 m. Owing to the improvement, this model supports measurement of optical fibers longer than 200 km and PON systems including up to 128 splitters. The MT9083 series also have an AR-coated, 7-inch LCD with excellent daylight visibility. In addition, the decrease in the number of parts and auto-power management function reduces the power consumption, extending the battery standby time to 12 hours and supporting a full day of field work without recharging. Figure 2 shows the block diagram of the MT9083 series, and table 2 at the end of the article lists the performance of models in the series.

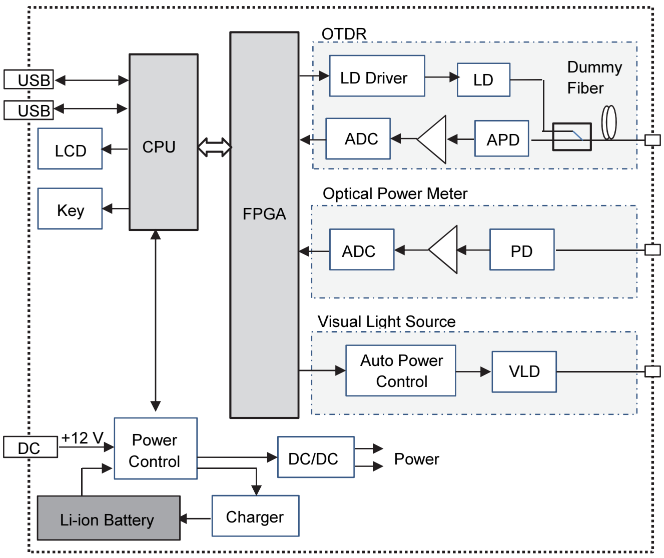

Figure 2 Block Diagram of MT9083 Series

2.2 OTDR Measurement Functions

The previous MT9083 series had the following three OTDR measurement modes:

- Standard mode
- Fault Locate mode
- Construction mode

The Standard mode is used for engineers with experience of OTDR measurements. The OTDR measurement parameters, such as measurement range, pulse width, etc., are set manually. In the Fault Locate mode, simply connecting the optical fiber and pressing the measurement Start button automatically sets the best measurement parameters for the connected fiber and displays events (fault points) in the fiber in an event table of results. In the Construction mode, preset parameters are used to simplify the work of confirming optical fiber paths while switching measured fibers.

The Fault Locate mode screen is shown in figure 3. This mode displays the fault location, detected far end, distance to and type of each event as well as the loss in an event table. Due to the large amount of numeric information, it is difficult to clearly understand the fault locations of the optical fiber at a glance. To improve these disadvantages, we have developed the new Fiber Visualizer function as a substitute for the Fault Location function.

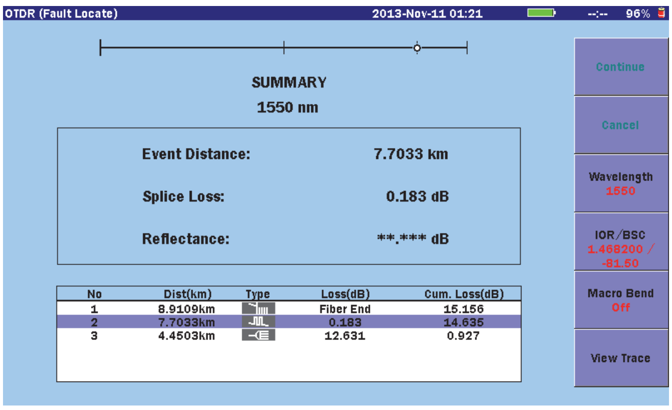

Figure 3 Fault Locate Mode Screen

3 Fiber Visualizer Function

3.1 Background

The Fiber Visualizer function enables operators with no special knowledge of OTDRs to make OTDR measurements easy. The development concept was to help operators see the test fiber installation conditions and fault locations at a glance.

3.2 Development Concept

Generally, at fiber cable works such as installation and maintenance, the most difficult problems when handling the OTDR are:

(A) Selecting best measurement settings for fiber under test

(B) Analyzing fault from measured waveform

Looking at problem (A) first, at OTDR measurement, the expected waveform cannot be obtained without selecting the best distance range and pulse width matching the fiber cable under test. For example, a setting mistake in the distance range makes it impossible to measure the fiber length accurately. In fact, there is even a risk of misidentifying a fault even when the optical fiber has no problems. As mentioned above, optical fiber cables are increasingly used to connect between the BBU and RRH in mobile access networks and many operators with no experience using OTDRs on-site find it difficult to select the best measurement settings.

In the case of problem (B), operators without a good understanding of optical fibers and OTDR characteristics may understand phenomena in measured waveforms such as loss due to bends and reflections but find it extremely difficult to analyze fault locations from the waveform and cannot easily perform Pass/Fail evaluations of the installed cable conditions.

To develop an OTDR that even novice operators with no knowledge of optical fibers and skills in using OTDRs can use, it is essential to understand these problems, so we designed the screens, operability, and improved performance based on the following concepts.

(1) Easy-to-understand screens:

Easy to see icons for at-a-glance Pass/Fail evaluations of fault and measurement results

So far, the Graphical User Interface (GUI) has been developed to display accurate measurement results in detail as its primary role while clear designs have been delayed for the most part. Although measurement results for each fault point are displayed in the Fault Locate mode, the large number of numeric figures makes it hard to grasp the installation condition of the optical fiber cable at a glance.

However, due to the explosive increase in the number of mobile terminals such as smartphone, many users tend to intuitively understand graphical images, especially icons. As a consequence, We completely renovated the GUI of the MT9083 series to graphical design and displaying important information to users using icons in an easy-to-unserstand arrangement made the evaluation of fault and measurement result into at-a-glance evaluation.

(2) Easy operability:

One-touch operation from measurement to Pass/Fail evaluation

To meet every possible situation, a wide variety of functions are incorporated in the MT9083 series, but conversely it is difficult to know which function is best to use for the many possible faults. As a result, the MT9083 series has a function for selecting measurement settings automatically as well as a function for auto-detecting fault points as in the previously described Fault Locate mode. However, depending on the user, the usage method and the measurement results may be difficult to understand, so these functions are not used sufficiently.

With this development, we pulled all these various functions together to support automated one-touch measurement with excellent operability for quick confirmation of results. We also added the the function which judges fiber condtion as Pass/Fail instead of relying on the operator expanding function of auto fault detection.

(3) Upgraded performance:

Improved fault detection accuracy

Considering the use in the field of mobile access, the distance ranges are about 200 m between the BBU and RRH or much shorter comparing to those used for conventional fiber installations field such as FTTH. To meet this need to support short distances, we improved the accuracy of the auto fault detectection.

3.3 Development Procedure

3.3.1 Design of Easy-to-Understand Screens

The procedure for designing easy-to-understand screens is described below.

As shown in figure 4, the Fiber Visualizer screen has four key elements: [1] Event icon, [2] Pass/Fail evaluation result, [3] Overall fiber map, [4] OTDR waveform of the event.

Item [1] the event icon, which is the most outstanding of these functions, uses a single icon to represent the type of event, its distance and the transmission loss. The operator can use this to easily confirm the required event information. Moreover, the event can be moved using the rotary encoder and magnified when it is focused, this made the operation intuitively.

Item [2], the Pass/Fail evaluation result, not only performs evaluation based on the analyzed event data but also displays either PASS or FAIL in large characters on the screen. As a result, the operator can confirm the evaluation result without needing to analyze the event data and OTDR waveform. If the result is FAIL, the icon for the problem event is displayed in red to give a clear indication of which event has a problem.

Item [3], the Overall fiber map, displays a map of the fiber as a bar graph with each event evaluation result marked by a color code, allowing the operator to see the positional relations of each event at a glance and to speedily find problem events along the fiber.

Item [4], the OTDR waveform, displays a magnified view of the waveform for the selected event at the bottom right of the screen to link and confirm the event type and measured waveform. Using this type of display makes it possible to visually confirm how the faults, such as optical connector reflections and bends, appear on OTDR waveform, and improving the skills and knowledge levels of operators with little experience in handling optical fibers and OTDRs. Additionally, pressing the Trace button at the bottom center of the screen supports confirmation of the entire OTDR waveform.

Achieving Fiber Visualizer design items [1] thru [4] has created an easy-to-understand screen for operators of every skill level.

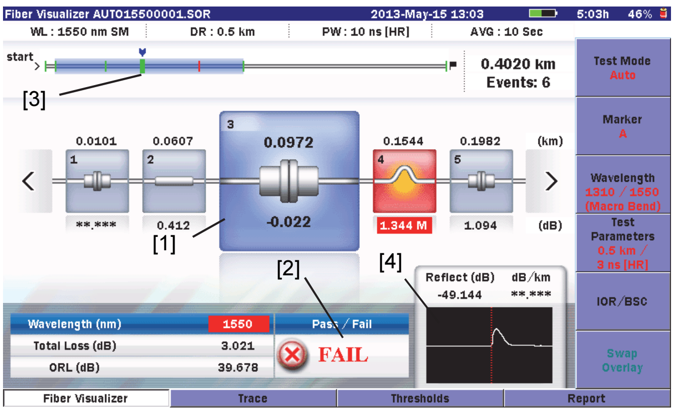

Figure 4 Example of Fiber Visualizer Screen

3.3.2 Design of Easy Operability and Upgraded Performance

This section explains development concepts (2) Easy operability, and (3) Upgraded performance. If a tester has many functions and settings, operations can often become complicated. However, with Fiber Visualizer, the simple 3-step procedure of just powering-up, connecting the fiber to be tested, and pressing the Start button, performs all the required OTDR settings and internal processing to analyze the faults based on the measured results and perform Pass/Fail evaluation, offering a "an easy-to-use OTDR for everyone."

However, although high-accuracy, one-touch detection of faults is possible by automatically selecting the best measurement settings, precision analysis of the faults based on the measured waveform is also necessary. As previously described, most mobile access uses optical fiber lengths ranging from 20 or 30 meters to several hundred meters. Moreover, measuring short optical fiber connection intervals of several meters with high spatial resolution is possible only with a very narrow pulse width. As a result, noise in the measured waveform become larger and the auto-setting and fault detection reproducibility are degraded sometimes for short distance ranges.

To solve these problems, Fiber Visualizer adds a new analysis mode with a new algorithm specialized for short-distance measurements. Figure 5 shows an example of measurement results obtained by using this algorithm. It shows that even events within 4 m of the optical connector can be detected with high precision.

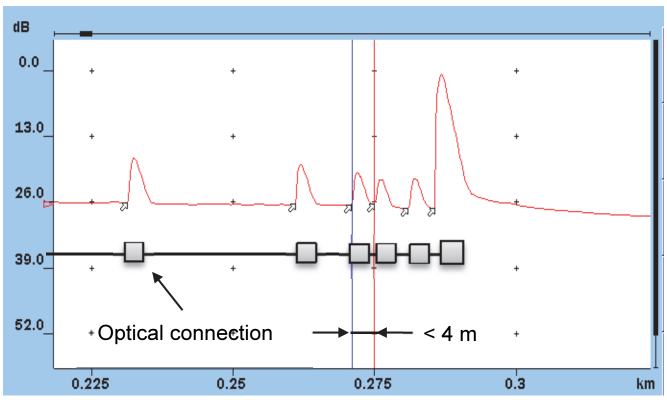

Figure 5 Example of event detection results at short fiber measurement

Another function handled by Fiber Visualizer is output of reports. Previously, to create a report, the results measured by the MT9083 series had to be saved as a waveform data file, such as SR4731, copied to USB or PC memory, and opened with Windows emulation software.

Using Fiber Visualizer, a pdf format file is created by the MT9083 itself, greatly improving work efficiency. An example of a created report is shown in figure 6. In addition to the header information, measurement conditions, event icons, and Pass/Fail evaluation results, the report also includes the overall OTDR waveform.

Figure 6 Example of Fiber Visualizer Report

4 Connector Inspection Function

4.1 Development Concept

As described in section 1, generally, any damages, dirts or scratches on the end face of the optical connector tip increase connection reflections and transmission loss, causing greatly degraded performance in the transmission path. Previous fiber connector inspections using a fiberscope required the operator to visually confirm whether the connector end face condition was good or bad, and depended heavily on the operator's skill level and experience, resulting in variable fiber connection conditions.

Quantifying the relationship between the length and width of scratches or damages on the end face and the levels of reflection or loss has been the subject of extensive research[5), 6)]. Based on this research, to systematize on-site fiber connector inspections and to guarantee a common level performance of fiber connection, the International Electrotechnical Commission (IEC) standardized Pass/Fail criteria in IEC61300-3-35[7)].

Until now, the MT9083 ACCESS Master simply displayed the fiberscope image, but this newly developed connector inspection function provides automated analysis based on the IEC61300-3-35 standard to support simple, effective and unified inspection of the fiber connector, irrespective of the operator. In addition, we have also developed a new compact, lightweight fiberscope option to help improve field workability even further.

4.2 Auto-Analysis Function

The auto-analysis function performs data analysis on each pixel of captured end face images to automatically detect the fiber center and the cladding edge and divides the zones defined in IEC61300-3-35. It then extracts scratches and dirts within each zone and performs Pass/Fail analysis according to the standards, as well as lists the analysis results. Table 1 shows an example of the evaluation abrasion standards for a SM fiber PC connector (reflection of ≥45 dB). To maintain connection quality, IEC61300-3-35 classifies the size and number of scratches and dirts in each zone for each connector type as well as the optical connector Pass/Fail standard.

Table 1 Example of SM Fiber PC Abrasion Standards

Zone	Zone Name	Scratches	Defects
A	Core	None	None
B	Clad	No limit <3 μm None >3 μm	No limit <2 μm 5 from 2 μm to 5 μm None >5 μm
C	Adhesive	No limit	No limit
D	Contact	No limit	None >10 μm

(Reflection attenuation of ≥45 dB, IEC613003-35)

Using this function, even operators with no experience of handling optical fibers can reliably perform Pass/Fail evaluation according to fixed standards, thereby assuring the connection quality of optical connectors. In addition, this function also supports to create a pdf file reporting the fiber connector end face analysis results linked to the previously described Fiber Visualizer report, greatly improving on-site work efficiency. Figure 7 shows an example of the Auto-Analysis function screen.

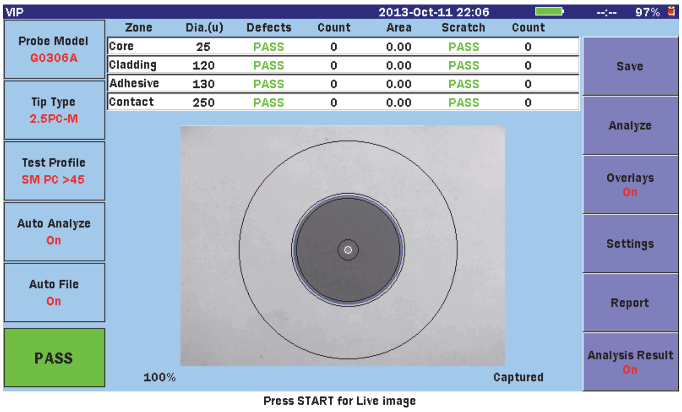

Figure 7 Example of Auto-Analysis Result Screen

Furthermore, we have also developed the MX900030A Connector Master™ application software to enable operators to do same work on Windows PC. This software suppors the same auto-analysis function as the MT9083, and reads captured image. For example, images captured in the field can be re-analyzed on a PC back at the office to help with reporting, etc. Figure 8 shows the MX900030A main screen.

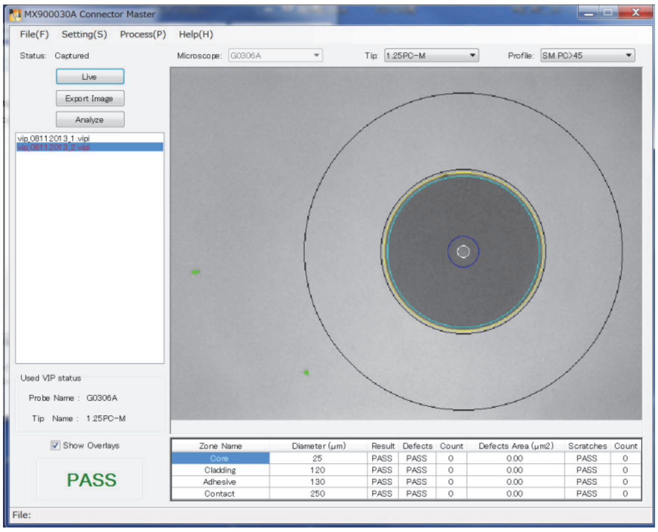

Figure 8 MX900030A Connector Master™

4.3 G0306A Fiberscope

Previous Anritsu' fiberscopes needed an external USB converter to convert analog signal to digital signal for the connection to the ACCESS Master, offering poor portability and making work difficult in the field. However, the new G0306A has a direct USB output coupled with a compact probe size of 46.5 (H) × 165 (W) × 31 (D) mm and a light weight of only 150 g. In addition, we employed Motion JPEG format which obtains 30 fps at VGA resolution (640 × 480). The minimum resolution per pixel is smaller than 1 µm. Figure 9 shows the external view of the G0306A and figure 10 shows a usage example.

Figure 9 External View of G0306A FiberScope

Figure 10 Example of G0306A Fiber Scope Use

5 Summary

To support an increase in volume of mobile data traffic, coaxial cables are replaced with optical fiber cables. Many field engineers with a lot of experience in handling coaxial cables have installed and maintained optical fiber cables. Hence an easy-to- use optical fiber tester is required to support their work. For this requirement, we have developed the Fiber Visualizer and optical connector tip inspection functions for the MT9083 ACCESS Master. Using these function, even operators with no experience of optical fiber cables can know the results of automated Pass/Fail analysis in the OTDR measurement and the fiber tip auto-analysis.

The excellent dynamic range and short dead zone performance of previous Anritsu OTDRs has clearly distinguished them from competing instruments. Moreover, the novel functions play a key role in helping operators with little prior experience in working with optical fibers. With the future anticipated expansion of mobile access, we hope more operators will take advantage of these new functions to help cut the number of fiber handling faults.

References

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Table 2 Key Performance of Models in MT9083 ACCESSMASTER Series

OTDR Performance

MT9083C2				
Options	Wavelength	Dynamic Range*1	Fresnel Deadzone	Backscatter Deadzone
MT9083C2-053	1310/1550 ±25 nm	46/46 dB	≤1 m ≤80 cm (typ.)	≤3.8/4.3 m
		25/25 dB (Pulse width: 100 ns)		
MT9083C2-057	1310/1550/1625 ±25 nm	46/46/44 dB		≤3.8/4.3/4.8 m
		25/25/23 dB (Pulse width: 100 ns)		
MT9083B2				
Options	Wavelength	Dynamic Range	Fresnel Deadzone	Backscatter deadzone
MT9083B2-053	1310/1550 ±25 nm	42/41 dB	≤ 1 m ≤80 cm (typ.)	≤5/5.5 m
MT9083B2-055	1310/1550 ±25 nm 1645 to 1655 nm	42/41/35 dB		≤5/5.5/6.5 m
MT9082B2-056	1310/1490/1550 ±25 nm	42/41/41 dB		≤6/6.5/6.5 m
MT9083B2-057	1310/1550/1625 ±25 nm	40/39/38 dB		≤6/6.5/7.5 m
MT9083B2-058	1310/1490/1550/1625 ±25 nm	42/41/41/40 dB		≤7/7.5/8.5 m
MT9083B2-063	1310/1550 ±25 nm (SMF) 850/1300 ±30 nm (MMF)	42/41 dB 29/28 dB		≤5/5.5 m ≤4/5 m
MT9083A2				
Options	Wavelength	Dynamic Range	Fresnel Deadzone	Backscatter Deadzone
MT9083A2-073	1310/1550 ±25 nm	39/37.5 dB	≤1 m ≤80 cm (typ.)	≤5/5.5 m
MT9083A2-055	1310/1550 ±25 nm 1645 to 1655 nm	38.5/37/34.5 dB		≤5/5.5/6.5 m
MT9083A2-057	1310/1550/1625 ±25 nm	37/35.5/32.5 dB		≤6/6.5/7.5 m
MT9083A2-063	1310/1550 ±25 nm (SMF) 850/1300 ±30 nm (MMF)	39/37.5 dB 29/28 dB		≤5/5.5 m ≤4/5 m

*1: Maximum pulse width unless specified otherwise

Common Specifications

<table>
<tr><td>Vertical Scale</td><td colspan="2">0.13, 0.33, 0.65, 1.3, 3.25, 6.5, 13 dB/div</td></tr>
<tr><td>IOR Setting</td><td colspan="2">1.400000 to 1.699999 (0.000001 steps)</td></tr>
<tr><td>Sampling Points</td><td colspan="2">Normal: 5001, High density: 20001 or 25001, Very high density: 100,001 or 150,001</td></tr>
<tr><td>Sampling Resolution</td><td colspan="2">5 cm (min.)</td></tr>
<tr><td>Reflectance Accuracy</td><td colspan="2">Single mode: ±2 dB, Multimode: ±4 dB</td></tr>
<tr><td>Distance Accuracy</td><td colspan="2">±1 m ±3 × measurement distance × 10^{-5} ± marker resolution (excluding IOR uncertainty)</td></tr>
<tr><td>Distance Range</td><td colspan="2">Single mode: 0.5, 1, 2.5, 5, 10, 25, 50, 100, 200, 300 km
Multimode: 0.5, 1, 2.5, 5, 10, 25, 50, 100 km</td></tr>
<tr><td rowspan="2">Dimension and Mass</td><td>Without Protector</td><td>Dimensions: 270 (W) × 165 (H) × 61 (D) mm, 10.6 × 6.5 × 2.4 inches
Mass: 1.6 kg, 1.9 kg including battery</td></tr>
<tr><td>With Protector (Option 010)</td><td>Dimensions: 284 (W) × 200 (H) × 77 (D) mm, 11.1 × 7.9 × 3 inches
Mass: 2.6 kg including battery</td></tr>
<tr><td>Display</td><td colspan="2">7-inch TFT-LCD (800 × 400, with LED backlight), indoor/outdoor type</td></tr>
<tr><td>Interface</td><td colspan="2">USB 1.1, Type A × 1 (memory), Type B × 1 (USB mass storage)</td></tr>
<tr><td>Data Storage</td><td colspan="2">Internal memory: 440 MB (up to 1000 traces)
External memory (USB): up to 30,000 traces with 512 MB</td></tr>
<tr><td>Power Supply</td><td colspan="2">12 V (dc), 100 V (ac) to 240 V (ac), Allowable input voltage range: 90 V to 264 V, 50 Hz/60 Hz</td></tr>
<tr><td>Battery</td><td colspan="2">Type: Lithium-ion
Operating Time: 12 hours, Telcordia GR-196-CORE Issue 2, September 2010
Recharge Time: <5 hours (power off)</td></tr>
<tr><td>Environmental Conditions</td><td colspan="2">Operating temperature and humidity: –10° to +50°C, <80% (non-condensing)
Storage temperature and humidity: –20° to +60°C, <80% (non-condensing)
Vibration: Conforming to MIL-T-28800E Class 3
Dust proof: MIL-T-28800E (Dust Exposure) Class 2
Drip proof: IP51 (IEC 60529), JIS C 0920 TYPE I</td></tr>
<tr><td>EMC</td><td colspan="2">EN61326-1, EN61000-3-2</td></tr>
<tr><td>LVD</td><td colspan="2">EN61010-1</td></tr>
</table>