GOING FUTURE TODAY.

# AOTDR

## Optical reflectometer




# Operating manual

Version 04-2021A

# Contents

# Before starting operation of the device

***HINWEIS:*** *Read this operating manual attentively! It contains important information about installation, ambient conditions and maintenance of the device. Keep this operating manual for future use and for handover in the event of a change of owner. A PDF version of this manual is available to download on the ASTRO website (there may be a more recent version).*

*The ASTRO company confirms that the information in this manual was correct at the time of printing, but it reserves the right to make changes, without prior notice, to the specifications, the operation of the device and the operating manual.*

# Symbols and conventions used

## Symbols used in these instructions

Pictograms are visual symbols with specific meanings. You will encounter the following pictograms in this installation and operating manual:

Warning about situations in which electrical voltage and non-observance of the instructions in this manual pose a risk of fatal injuries.

Warning about various dangers to health, the environment and material.



Warning about thermal dangers (risk of burns).

Warning about high laser radiation emitted from a device, connector or adapter (risk of eye damage).

Recycling symbol: indicates components or packaging materials which can be recycled (cardboard, inserts, plastic film and bags). Used batteries must be disposed of at approved recycling points. Batteries must be completely discharged before being disposed.

This symbol indicates components which must not be disposed of with household rubbish being disposed of.

## Proper use

The reflecotmeter has been designed for measuring Silica-based optical fibres for telecommunications. Do not attempt to use this device for other applications. Misuse of the device may result in electric shock, fire and/or serious personal injury. Modification of the devices or use for any other purpose is not permitted, and will immediately void any guarantee provided by the manufacturer.

## Target group of this manual

The target group for installation and starting operation of the ASTRO optical transmission technology are qualified experts who have training enabling them to perform the work required in accordance with EN 60728-11 and EN 62368-1. Unqualified persons are not allowed to install and start operation of the device.

# Important safety information

To avoid any hazardous situations to the extent possible, you must adhere to the following safety information:

*ACHTUNG:* ***Failure to observe this safety information may result in personal injury due to electrical and thermal dangers!***

**Proper use**

- ☐ Only use the device at the approved operating sites and in the ambient conditions allowed (as described in the following), and only for the purpose described in the section “Proper use”.

**Before starting operation of the device**

*HINWEIS:* *Read this operating manual attentively! It contains important information about installation, ambient conditions and maintenance of the device. Keep this operating manual for future use and for handover in the event of a change of owner or operator. A PDF version of this manual is available to download on the ASTRO website (there may be a more recent version).*



- ☐ Check the packaging and the device for transport damage immediately. Do not start operation of a device that has been damaged.
- ☐ Transporting the device by the power cable may damage the mains cable or the strain relief, and is therefore not permitted.

**Danger of optical radiation**

This product is laser class 1M (according IEC 60825-1 Safety of Laser Products) and therefore several safety precautions must be applied.

- ☐ Exposure to class 1M laser radiation is possible on open connectors or connected fibre patch cords. Do not view exposed fibre or connector ends when handling or maintaining optical equipment. Do not view with optical instruments into open connectors or fibre ends on switched on devices. Make sure all wherever a fibre inspection is required, that the inspected fibre or connector is completely optical radiation free.
- ☐ Due to the high optical radiation and improper handling of optical fibre connections and devices, there could be risks for the operating and service personnel. Access should be restricted to trained personnel only.

- Never look directly or with optical inspection tools into the end of a fibre which is connected to a transmitter or optical amplifier and which is in operation. If the eyes are exposed to optical radiation, which are above the acceptable maximum, this could cause permanent damage to the eye.

**Installation, operation, maintenance**

- The electrical connection conditions must correspond to the specifications on the device type plate.
- The ambient temperatures specified in the technical data must be complied with, even when climatic conditions change (e.g. due to sunlight). If the device overheats, the insulation used to isolate the mains voltage may be damaged.
- The device and its cable may only be operated away from radiant heat and other sources of heat.
- To avoid trapped heat, ensure there is good ventilation on all sides.
- No objects may be placed on the device.
- The device does not feature protection against water and may therefore only be operated and connected in dry rooms. It must not be exposed to spraying or dripping water, to condensation, or to similar sources of moisture.



- All adhere to all applicable national safety regulations and standards.
- The device is operational when connected to the mains power or if the provided Lithium battery is charged and inserted into the battery compartment of the device.

- Excess mechanical loads (e.g. falling, impacts, vibrations) may damage insulation used to provide protection from mains voltage.
- High excess currents (lightning strike, surges in the power utility grid) may damage insulation used to provide protection from mains voltage.
- If there is no information about intended use (e.g. operating site, ambient conditions), or the operating manual does not include the corresponding information, then you must consult the manufacturer of this device to ensure that the device may be installed. If you do not receive any information on this from the manufacturer, do not start operating the device.
- Verify that the product is set to match the available line voltage, the correct fuse is installed, and all safety precautions are taken.

- Do not operate the instrument in the presence of flammable gases or fumes.
- Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made only by qualified service personnel.
- Stop using the device when it malfunctions. (See section „Maintenance and repair“).
- Users must disconnect the AC power cord from the AC adapter inlet or the wall socket (outlet) immediately if they observe the following or if the splicer receives the following faults: Fumes, bad smell, noise, or over-heat. Liquid or foreign matter falls into cabinet. Splicer is damaged or dropped. If this occurs, ask our service center for repair. Leaving the splicer in a damaged state may cause equipment failure, electric shock or fire and may result in personal injury, death or fire.
- Use only the AC adapter / battery charger designed for this splicer. Using an improper AC power source may cause fuming, electric shock or equipment damage and may result in personal injury, death or fire.
- Do not disassemble or modify the device, AC adapter or battery. In particular, do not remove or bypass any electrical or mechanical device (e.g. a fuse or safety switch) incorporated into the design and manufacturing of this equipment. Modification could cause damage that may result in personal injury, death, electric shock or fire.
- Never operate the device in an environment where flammable liquids or vapors exist. Risk of dangerous fire or explosion could result from the splicer’s electrical arc in such an environment.
- Do not use compressed gas or canned air to clean the device. They may contain flammable materials that could ignite during the electrical discharge.
- Check the AC power source before use: Proper AC power source is AC 100-240 V, 50-60 Hz. Proper DC power source is DC10-12V. Improper AC or DC power source may cause fuming, electric shock or equipment damage and may result in personal injury, death or fire.
- AC generators commonly produce abnormally high AC output voltage or irregular frequencies. Measure the output AC voltage with a circuit tester before connecting the AC power cord. Such abnormally high voltage or frequency from a generator may cause fuming, electric shock or equipment damage and may result in personal injury, death or fire. Make sure the generator is regularly checked and serviced.

- Do not modify, abuse, heat or excessively pull on the supplied AC cord. The use of a damaged cord may cause fuming, electric shock or equipment damage and may result in personal injury, death or fire.
- Do not short-circuit the terminals of AC adapter and optional battery. Excessive electrical current may cause personal injury due to fumes, electric shock and equipment damage.
- Do not touch the device, AC power cord and AC plugs with wet hands.This may result in electric shock.
- Do not operate the device near hot objects, in hot temperature environments, in dusty/humid atmospheres or when water-condensation is present on the device. This may result in electric shock or malfunction**.**
- When using Li-ion battery, follow the instructions below. Failure to follow these may result in explosion or personal injury.
  Do not charge battery with other methods than instructed.
  Do not discard battery into an incinerator or fire.
  Do not charge or discharge battery near a flame or under direct sunlight.
  Do not excessively shake or jar the battery.
  If battery leaks of liquid residue, be careful handling the battery so the liquid does not get in skin or eye contact. If it reaches contact, immediately wash skin or eyes thoroughly and see the doctor. Dispose of the battery and call the service center for replacement.
  If charge did not complete in four hours or the Charge LED is constantly on, immediately stop charging and call the service center for repair.
- Do not store the device in any area where temperature and humidity are extremely high. Possible equipment failure may result.
- Operating personnel is not allowed to remove instrument covers. Component replacement and internal adjustments must be made only by qualified service personnel.

### Maintenance

- The operating display only shows whether the DC current, which supplies the device components, has been disconnected. However, operating displays (on the power supply unit or the device) that are not lit up in no way indicate that the device is completely disconnected from the mains.
- Read carefully: EN 60728 - Part 1 Safety requirements: No service work during thunderstorms.

### Repair

- Repairs may only be performed by the manufacturer. Improperly performed repairs may result in considerable dangers for the user.
- If malfunctions occur, the device must be disconnected from the mains and authorised experts must be consulted. The device may need to be sent to the manufacturer.

# Description of performance

The optical reflectometer AOTDR has the following characteristics:

- wavelength 1310/1550 nm
- range 26 dBm/24 dBm
- dead zone 1/6 m
- pulse width 3 ns, 5 ns, 10 ns, 20 ns, 50 ns, 100 ns, 200 ns, 500 ns, 1 µs, 2 µs, 5 µs, 10 µs, 20 µs
- 4 GB internal storage for up to 40.000 measurements
- 3x USB port (2x USB A Type,1x Micro-USB)
- output in Excel format
- 5 inch TFT display (touch screen)
- 7.4 V/3300 mAh lithium battery, working time about 6 h / charging time 3,5 h
- operating temperature range -5 .. +40 °C
- FC/UPC connector
- optional visual fault locater (650 nm)
- optional optical power meter (-60 ..+5 dBm, /850 /1300 /1310 /1490 /1550 /1625 /1650 nm)



*HINWEIS: The device is equipped with an LCD monitor, manufactured in a high quality-controlled factory environment. However, some black dots may appear, or red/blue/green dots may remain on the screen. The screen brightness may not appear uniformly depending on viewing angle. Note that these symptoms are not defects, but are nature of LCD.*

# Warranty conditions

The general terms and conditions of ASTRO Bit GmbH apply. You will find these in the current catalogue or on the Internet under “www.astro-kom.de”.

# Disposal

All of our packaging material (cardboard boxes, inserts, plastic film and bags) is completely recyclable. Electronic devices must not be disposed of with household waste, but rather – according to DIRECTIVE 2012/19/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL from 4 July 2012, on waste electrical and electronic equipment – must be properly disposed of. When it is no longer of use, please bring the device for disposal to one of the public collection points for this purpose.

ASTRO Bit is a member of the Elektro system solution for the disposal of packaging materials. Our contract number is 80395.

# Device description

## Scope of delivery

- ☐ Power adapter
- ☐ Power patchcord
- ☐ Data cable
- ☐ CD
- ☐ Carrying case
- ☐ Securing strip
- ☐ Operating manual

## Optional accessories

- ☐ VFL (Visual Fault Locator) module
- ☐ OPM (Optical Power Meter) module

CE

The AOTDR features a CE marking. This confirms that the product conforms to the relevant CE directives and adheres to the requirements specified therein.

[1] Port 1
[2] Arrow buttons
[3] Indicator LED
[4] Port 2
[5] Test buttons
[6] Button area

## AOTDR reflectometer

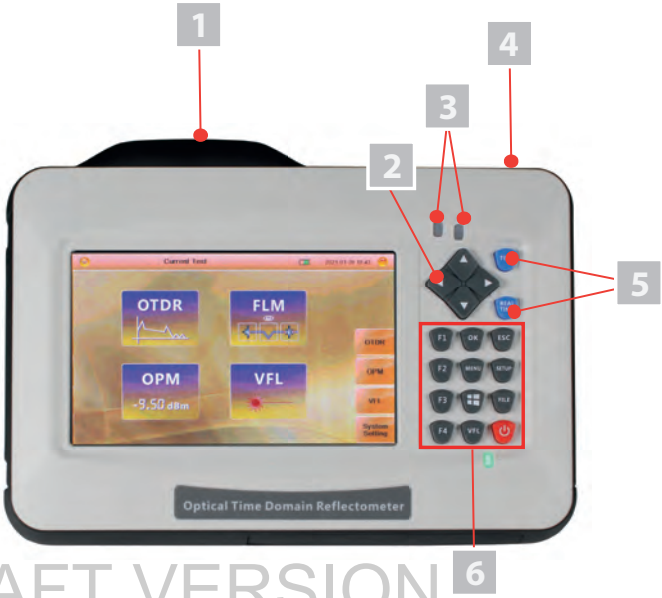





*Figure 1: AOTDR*

- `Port 1:` Includes AOTDR Test port (FC/UPC), Visual Fault Locator port (optional), Power Meter port (optional), Touch pen and 2x USB A type
- `Arrow buttons:` Move the cursor, navigate between menus or files
- `Indicator LED:` Indicate test and power state
- `Port 2:` Micro USB and charging port
- `Test buttons:` Averaging test and realtime test button
- `Button area:`
  F1 - F4: Select relative tag menu
  OK: Confirm setting or enter menu
  ESC: Cancel setting
  MENU: Go back to main menu
  SETUP: Set test parameters
  FILE: Open file manager
  VFL: Open visual fault locator menu
  Screen symbol button: Make screenshot
  Red button: Power on

[1] Side menu
[2] Function modules area
[3] Basic state information area

## Main menu interface

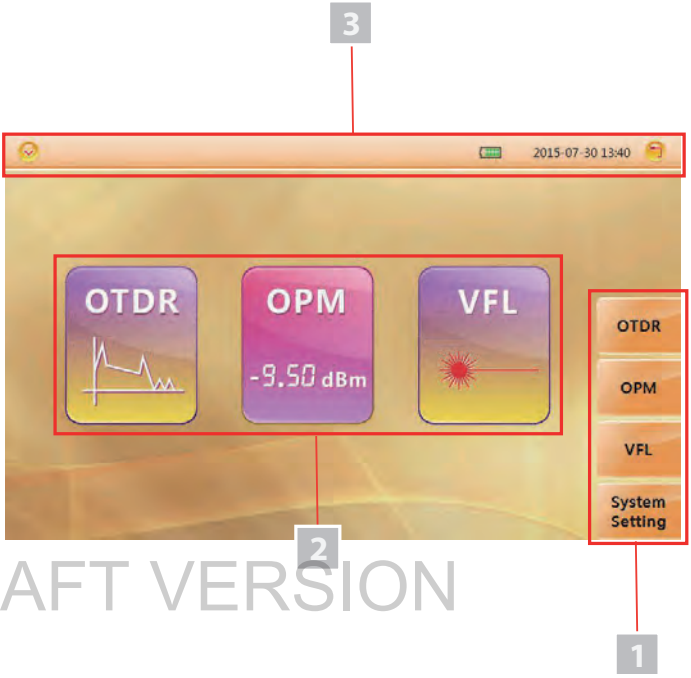





*Figure 2: Main menu interface*

- `Side menu:` Here you can enter different submenus.
- `Function modules area:` Here you can enter the settings for the modules OTDR (Reflectometer), OPM (Optical Power Meter) and VFL (Visual Fault Locator).
- `Basic state information area:` displays date, time and charging status of the battery

[1] Thumbnail of current curve
[2] Curve display and operating area
[3] Event list area
[4] Test condition information areas

## OTDR module interface

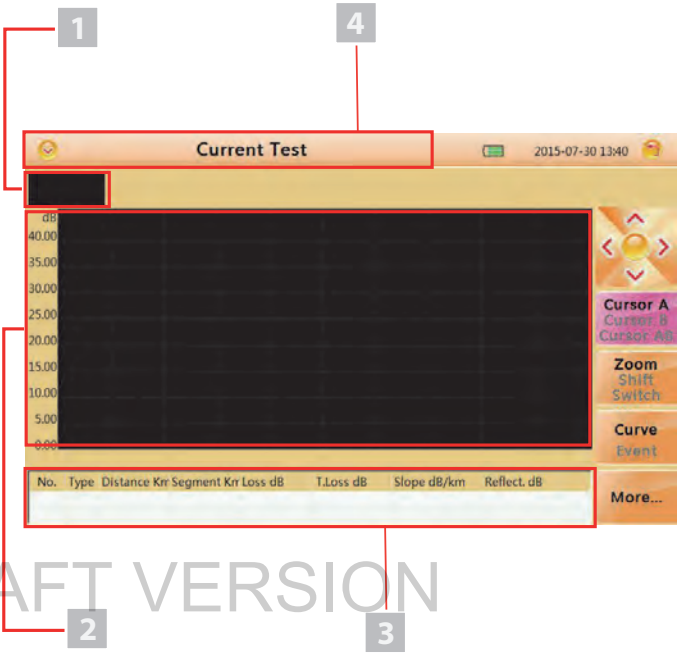





*Figure 3: OTDR menu interface*

- `Thumbnail of current curve:` for user's reference to the integrated curve
- `Curve display and operating area:` displays events and curves
- `Event list area:` displays event information including: „Type", „Distance (Km)", „Loss (dB)", „T.Loss (dB)", „Slope (db/Km)" and „Reflection (dB)"
- `Test condition information area:` displays condition information of test including: „PW (pulse width)", „WL (wave length)", resolution of x axis and y (dB/div), distance, averaging and total loss from cursor A to cursor B

### VFL module interface

[1] VFL mode indicator
[2] Launching state indicator

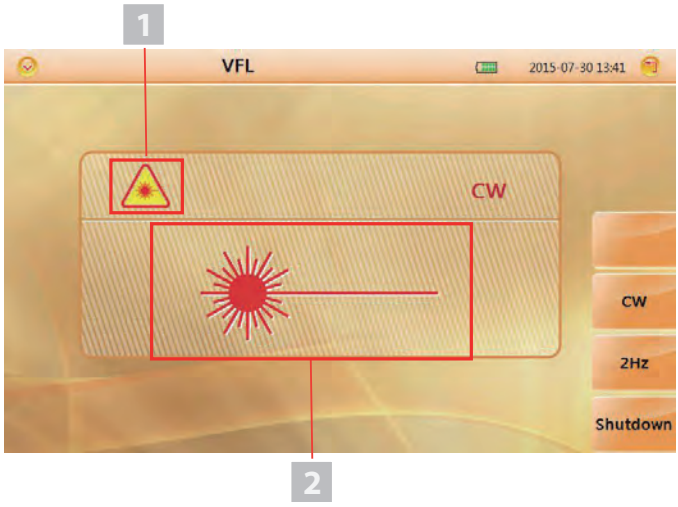



*Figure 4: VFL menu interface*



### OPM module interface

[1] Power value
[2] Wavelength channel
[3] Reference value

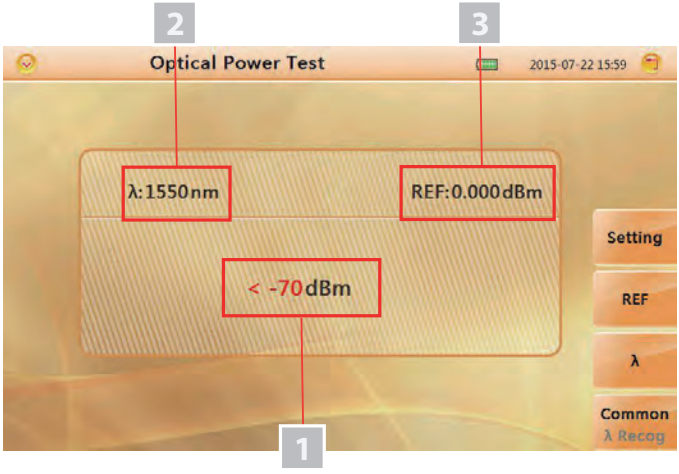
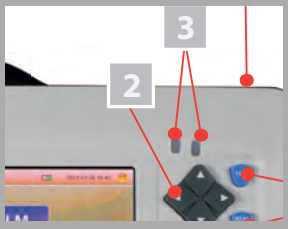



*Figure 5: OPM menu interface*

# Preparation




**Turning the device on**

Press the power button of the AOTDR for more than two seconds until the power state indicator [3, left LED] turns green. When battery power is low, a warning message will be displayed on the screen.

Power state indicator:

- `Green light:` working state or fully charged
- `Red light:` charging state

The second LED indicates the launching state when testing.

Launching state indicator:

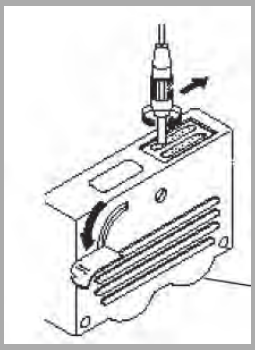
- `Green light:` proceed realtime test
- `Red light:` proceed averaging test

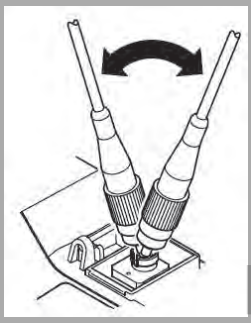
*HINWEIS: In case of low power, a special icon will appear, and after that the AOTDR will turn off automatically for a while. If it has not been used for an extended period of time, the device will turn off immediately after turned on to protect the internal battery. In this case please connect the AC adapter. Proper charging temperature is: -10...+50 °C. High charging temperature may shorten battery life. Charging time is about 5 hours with power on and about 3 hours with power off. Don't charge the battery more than 8 hours!*



**Connecting the fibre**

*HINWEIS: Before connecting fibre to the AOTDR, clean the fibre end first. Dust on the end of the connector may damage the optical port or reduce test quality!*





To clean the fibre do the following:

- ☐ Put the connector of the fibre against the cleaner.
- ☐ Press the handle of the cleaner.
- ☐ Rub each other carefully to clean the contaminant.
- ☐ Repeat step 1-3.
- ☐ Open the protecting cover of the optical port of the AOTDR.
- ☐ Insert the connector of the fibre carefully into the optical port.

***HINWEIS:*** *Insert the connector carefully into the optical port. Avoid inclined insertion like seen on the picture to the left. Unproper operation may cause the damage of the optical port!*

***HINWEIS:*** *Before connection make sure that there is no optical signal inside the fibre. Any signal which is larger than -30 dBm will disturb the sampling of the AOTDR, or even cause permanent damage of the sensor.*

# Introduction to measuring with the AOTDR

**The purpose of measuring**

The AOTDR shows the back-scatter light power of the optical signal relative to the distance. With this information, the OTDR can measure a series of important information of an optical fibre such as the quality of the line, distance of the line, etc.

**Content of measurement**

- event position - a broken point or the end of the tested fibre
- optical attenuation coeficient of an optical fibre
- single event loss, such as the loss of a connection or a macro bending or the loss of an end-to-end line on the tested optical fibre

**Analyzing a curve**

The AOTDR can auto analyze a tested trace, the position process shows below:

- Get the reflection events generated by connectors or a mechanical splicer.
- Non-reflection events (usually splicing points or macro bending)
- End: The first point which the loss of it is over the threshold would be scanned as the end of a trace.
- Events list: event type, loss, reflection and distance



Normal curve:

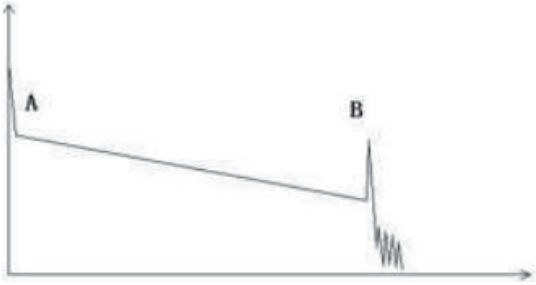



*Figure 6: normal curve*

A normal trace shows as above, the A mark is a start-peak and the B mark is an end-reflection-peak. The tested trace is oblique, the total loss will become bigger with the increasing of the fibre length. The total loss (dB) divided by the total length is the average loss (dB/km) of a fibre.

Curve with a jumper connected:

*Figure 7: curve with a jumper connected*

If there is an additional reflection peak in a tested trace, this may be caused by a connection point or some other reasons. Anyway, the appearance of the reflection peak shows that the two connecting surfaces of the connection are smooth. The smoother the connection surfaces are, the higher the reflection peak is. For instance, if a broken optical line is under test, the OTDR trace will show a broken point. After a maintenance of this line, use the OTDR to test it again. You may see a reflection peak replacing the broken point on the OTDR trace. This shows the maintenance is done.

Curve with a broken point:



*Figure 8: curve with a broken point*

If the tested trace is just like the figure shows above, this might be caused by several reasons like: a bad connection between the connector and the lunching port, the optical pulse cannot be launched into the optical fibre or a short distance broken point of the tested fibre from the initial connection and the preset testing distance and pulse width is larger.
To fix this problem you should:

- ☐ Check the connection of the connector and the launching point.
- ☐ Reset the test parameters and decrease the preset distance and the pulse width.

If the problem still exists, you could estimate:

- ☐ The connector of the test fibre is broken or polluted.
- ☐ The launching port on the AOTDR is broken or polluted.
- ☐ The distance of the broken point or the distance from the initial connection is too close.

Curve with non-reflective event:

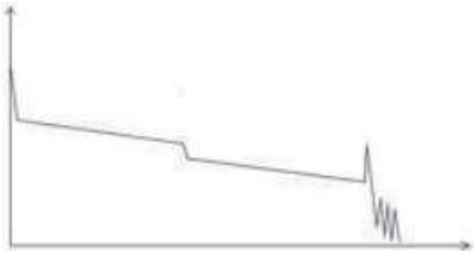


*Figure 9: curve with non-reflective event*

There is a common phenomenon that an obvious step is on the middle of a tested trace. It is often caused by a fibre bending, fibre knot, being pressed by something heavy or a fuse splicing point. The step means a bigger loss of a fibre. It is also called event point. If the direction of it is downward, it can be called non-reflection event. If the direction is upward, we can call it reflection event. Sometimes, the loss value can be a negative value, it does not mean the loss does not exist. It is a common phenomenon called pseudo gain, caused by a connection of two fibres with different back scatter coefficient. The scatter coefficient of the back fibre is larger than the front one's. In addition, the different refract ratio can also cause this phenomenon. To avoid it, you can test a fibre bi-directionally.



Abnormal condition:

*Figure 10: abnormal condition*

The situation that there is no reflection peak at the end of a trace, as shown above, should be paid attention on. If the distance of the tested fibre is known and the distance shown on the AOTDR is not equal to the real distance, this shows that the fibre might be broken down or twisted and the maximum bending radius of it is exceeded. The distance shown on the AOTDR is the position of the fault point.
This phenomenon is often used in maintenance. If a fibre is uncertain, you can bend a fibre and make sure the maximum bending radius is exceeded, then use the real time testing function of the AOTDR to confirm the fibre.

Distance is too long:

*Figure 11: distance is too long*



This situation often happens in a long distance testing, caused by unsuffient dynamic range of the OTDR. The energy of it can not support a long distance transmission caused by a too low preset testing range of distance or pulse width corresponding to the actual fibre length. To avoid this situation, adjust the testing distance and the pulse bigger and extend the sampling time.

## How the AOTDR works

The OTDR (Optical Time Domain Reflector) is a high precision optical testing meter that is based on the theory of Rayleigh scattering and Fresnel reflection. It is widely used in the maintenance, construction and monitoring of an optical line. All the important parameters like fibre length, optical loss, connection loss, broken or twisted points etc. of a fibre can be shown on the OTDR. When the light transmits along a fibre, it will be scattered to various directions caused by the difference of some properties of the transmission medium. This phenomenon is called Rayleigh scattering. During the scattering process, some of the light will be scattered along the absolutely converse direction. This phenomenon is called Rayleigh back-scattering. It provides some details about the fibre length. The parameter fibre length can be calculated with the time parameter (This is the derivation of „TD“ in the OTDR - Time Domain).
These back-scattering signals show the loss level of a fibre and by using this information, the OTDR can generate a backward oblique trace which reflects several important attributes of an optical fibre. When the light transmits downward along the fibre and meets a medium of different density, a part of the light will be reflected. This phenomenon is called Fresnel reflection. There are many reasons that can cause the change of the medium density, ike a little slot at the splicing point, a broken fibre etc. This phenomenon is usually used to locate the discontinuous point. Compared to the Rayleigh scattering, the consumed amount of light in Fresnel reflection is much more then it is in Rayleigh scattering. The power of Fresnel reflection is tens of thousands times to the back-scattering's. The reflection level depends on the grade of the refraction ratio.

Formula for the distance: **distance = (c/n) x (t/2)**
c: light speed in vacuum
t: delay time between launching pulse and receiving pulse
n: refraction ratio of the tested fibre



When displaying the whole trace, each point of the trace represents the average value of several sampling points. By using the zoom in and zoom out function, the value of each sampling point can be determined.

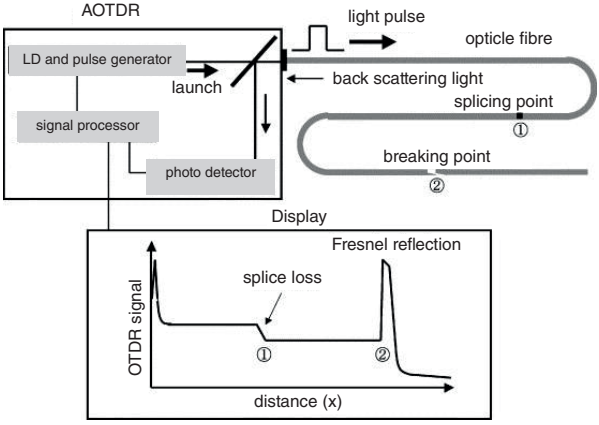



*Figure 12: working principle of the AOTDR*

### Event types

The events on trace are all the points that the value of power loss fluctuates abnormally. It usually contains various types of connection and bending, crack, broken etc. The event points marked on trace with special marks are the abnormal points in a fibre that cause the excursion of a normal trace.

Start event:

The start event on a OTDR trace is the initial point. Under the default setup, the start event is located on the first event (usually it is a connection between the OTDR launching port and the connector of a fibre) of a fibre. It is a reflection event.

End event:

The end event on a OTDR trace is the end point of a fibre. Under the default setup, the end event is located on the last event (usually it is an end face or a broken down point of a fibre). Usually, it is a reflection event.

Reflection event:

The phenomenon on a trace that some power of the optical pulse is reflected is called a reflection event. A reflection event is displayed as a peak signal on a trace.

# Setting measurement conditions

Press the SETUP button on the device to enter the test setting interface. You will see the following screen now:

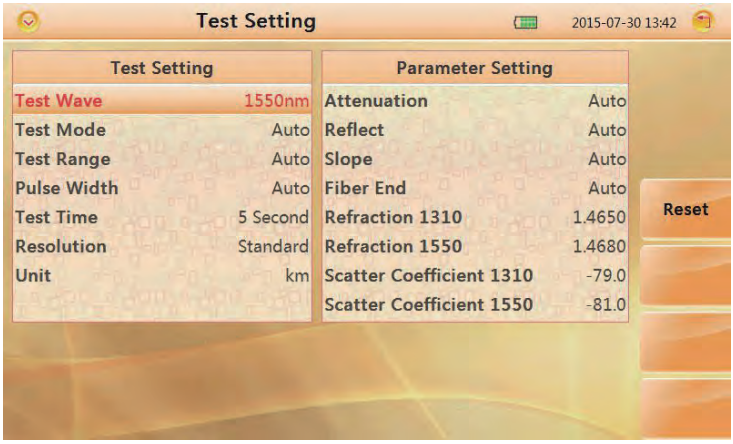



*Figure 13: Test setting interface*



The meaning of the different items are:

- `Test Wave:` test wavelength of the OTDR, including 1310nm, 1550 nm and 1310 nm & 1550 nm (3 different modes)
- `Test Mode:` Auto Mode: The AOTDR will set the best parameters for the current test. Manual Mode: Parameters can be set manually.
- `Test Time:` Under average test mode (TEST), a longer test time has better SNR (Signal Noise Ratio) but takes more time.
- `Test Range:` Test distance of the AOTDR. Can only be adjusted in manual mode; in auto mode this item is set as "Auto".
- `Pulse Width:` A wider pulse has a stronger backward signal, but wide pulse width will cause the saturation of the backward signal and make the blind area bigger. So the selection of pulse width has close relationship to the length of the fibre. Long fibre has a wide pulse width. The pulse width can only be modified in "Manual" mode.
- `Resolution:` Sampling resolution of a high resolution test has more sample points and high precision,but takes more memory space.
- `Unit:` unit of test result (km, kfeet and miles selectable)

### Auto mode

In „Auto mode“ you can just proceed with the test by setting a proper wavelength.
For testing in „Auto mode“ proceed as follows:

1. Press the SETUP button to enter the test setting interface.
2. Select „Auto mode“ in test setting column on the left side of the screen:

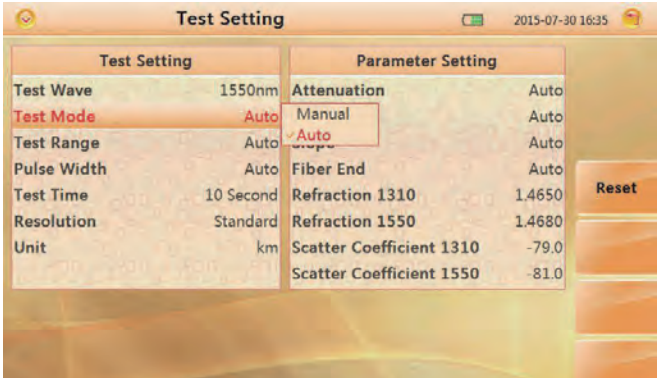



*Figure 14: selecting „Auto mode“*



3. Select the test wavelength:

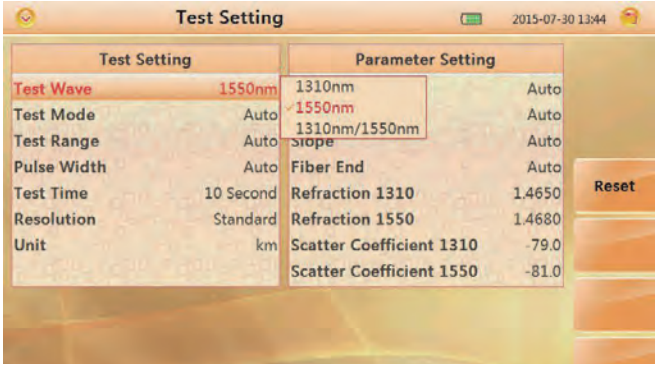



*Figure 15: selecting the test wavelength*

***HINWEIS:*** *The „Auto mode“ is not suitable to perform a blind area test. You must enter "Manual mode" and choose "Blind area test" to perform the blind area test.*

### Manual mode

In „Manual mode“ you can set the range and pulse width manually.
For testing in „Manual mode“ proceed as follows:

1. Press the SETUP button to enter the test setting interface.
2. Select „Auto mode“ in test setting column on the left side of the screen:

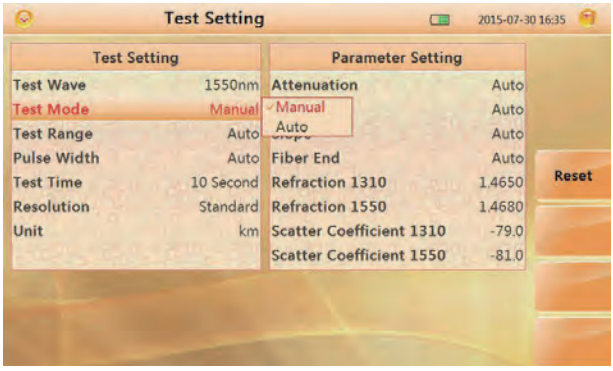



*Figure 16: selecting „Manual mode“*



3. Select the test wavelength:

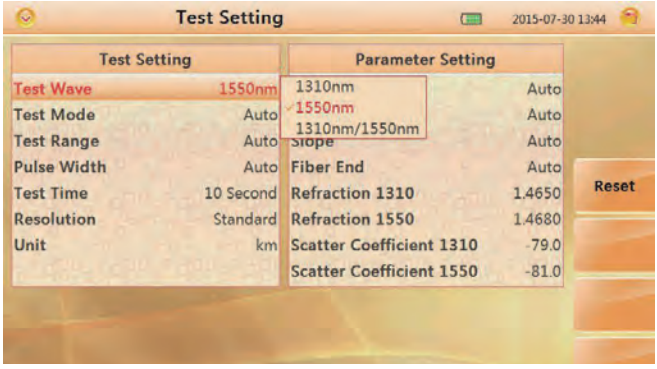



*Figure 17: selecting the test wavelength*

4: Set the range and the pulse width:

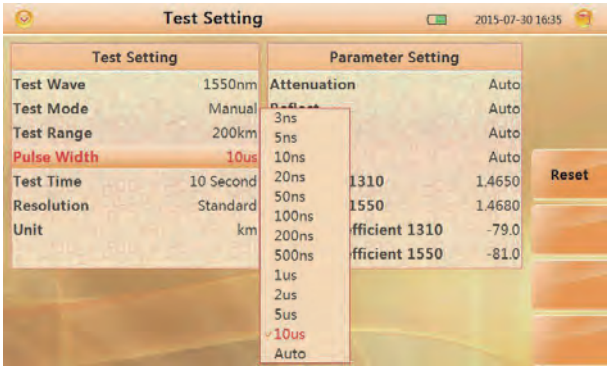



*Figure 18: setting the range and pulse width*

***HINWEIS:*** *When "Pulse width" is set to "Auto", the test will choose the proper pulse width automatically. When "Test Range" is set to "Auto", the test will choose the proper range automatically. Once you set the "Test range", the „Pulse width"item will adjust automatically. You can also adjust it manually.*

Proper relationship between range (MR) and pulse width (PW) for user's reference:

| MR / PW | 100 m | 500 m | 2 km | 5 km | 10 km | 20 km | 40 km | 80 km | 120 km | 160 km | 240 km |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 ns | √ | √ | △ | △ | △ | △ | △ | △ | △ | △ | △ |
| 5 ns | √ | √ | √ | △ | △ | △ | △ | △ | △ | △ | △ |
| 10 ns | △ | √ | √ | √ | △ | △ | △ | △ | △ | △ | △ |
| 20 ns | △ | √ | √ | √ | √ | △ | △ | △ | △ | △ | △ |
| 50 ns | △ | △ | √ | √ | √ | √ | △ | △ | △ | △ | △ |
| 100 ns | △ | △ | △ | √ | √ | √ | △ | △ | △ | △ | △ |
| 200 ns | △ | △ | △ | △ | △ | √ | √ | △ | △ | △ | △ |
| 500 ns | △ | △ | △ | △ | △ | △ | √ | √ | △ | △ | △ |
| 1 µs | △ | △ | △ | △ | △ | △ | √ | √ | √ | △ | △ |
| 2 µs | △ | △ | △ | △ | △ | △ | △ | √ | √ | √ | △ |
| 5 µs | △ | △ | △ | △ | △ | △ | △ | √ | √ | √ | √ |
| 10 µs | △ | △ | △ | △ | △ | △ | △ | △ | √ | √ | √ |
| 20 µs | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | √ |



*Figure 19: Relationship between range and pulse width*

# Making measurements

The AOTDR has two test modes: averaging test mode and realtime test mode.

**Averaging test mode**

Averaging test mode can calculate the data of a curve over a period of time and display as an averaging one. The test time can be set via the "Test Time" menu in the "Test Setting" section.
Press the TEST button on the control panel of the device. The test state indicator LED turns red and the averaging test interface is displayed:

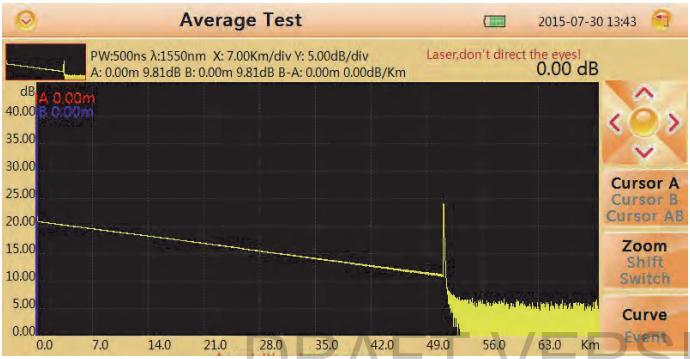





*Figure 20: Averaging test interface*

**Realtime test mode**

In realtime test mode you can check the network and adjust the test range and pulse width in real time.
Press the REALTIME button on the control panel of the device. The test state indicator LED turns green and the realtime test interface is displayed:

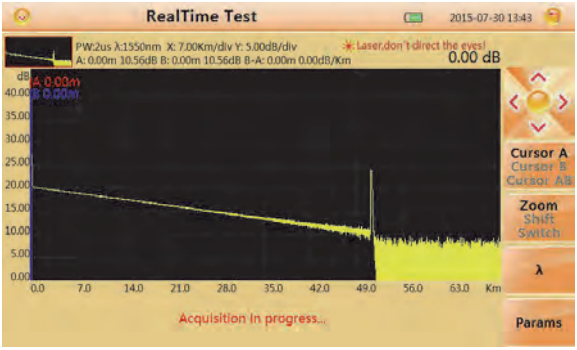



*Figure 21: Realtime test interface*

Selecting the wavelength:

- ☐ First press the „λ“ button on the right side of the display. Then select 1310 or 1550 nm on the display.
- ☐ Confirm by pressing the OK button on the control panel of the device.

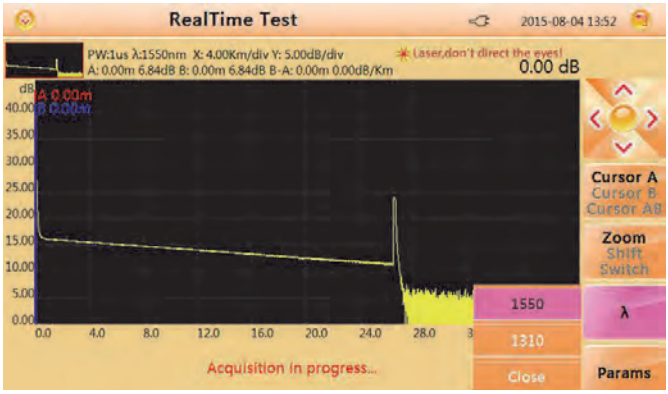



*Figure 22: Selecting the wavelength*



Selecting the test range and pulse width:

- ☐ First press the „Param“ button on the right side of the display. Then select the test range and pulse width by pressing one of the radio buttons.
- ☐ Confirm by pressing the OK button on the control panel of the device.

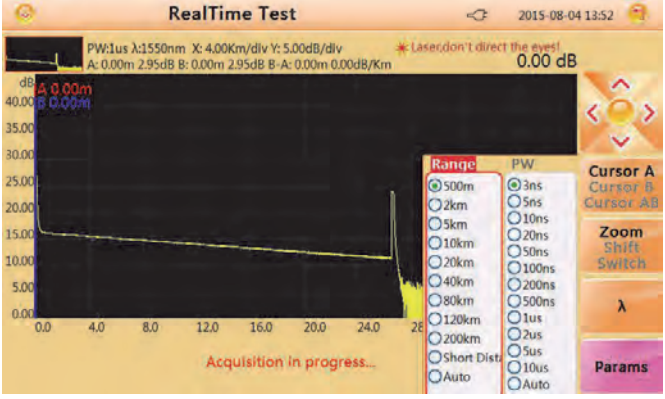



*Figure 23: Selecting the test range and pulse width*

## Event lists

After the test an event list will appear immediately at the bottom of the screen. It shows detailed information of the test.

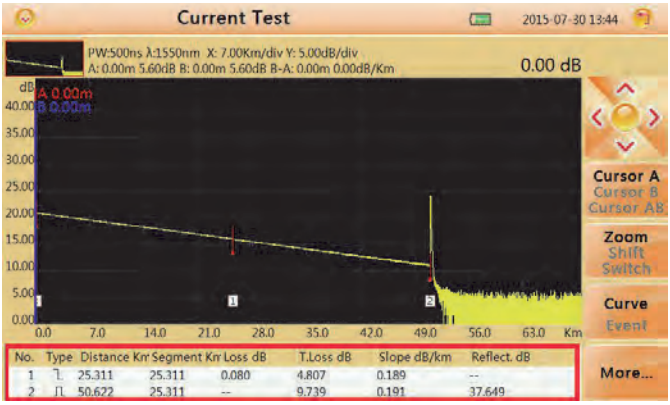



*Figure 24: Event list*



The following parameters are displayed in the event list:

- `Type:` Type of event (attenuation event, reflection event or end event)
- `Distance:` Distance from start point to event
- `Section:` Distance from this event to the last event
- `Loss:` Loss of this event (in dB)
- `T. Loss:` Total loss from start event to this event (in dB)
- `Slope:` Ratio of event loss value (from this event to last event) to the distance value (distance from this event to last event) in dB/km
- `Reflect.dB:` Return loss of this event (in dB)

## Distance measurement

You can measure the distance from one point to another:

- Press the F1 button on the control panel to activate the cursor function
- Use the arrow buttons on the control panel to move cursor A or B.

The following guide shows what information you can get:

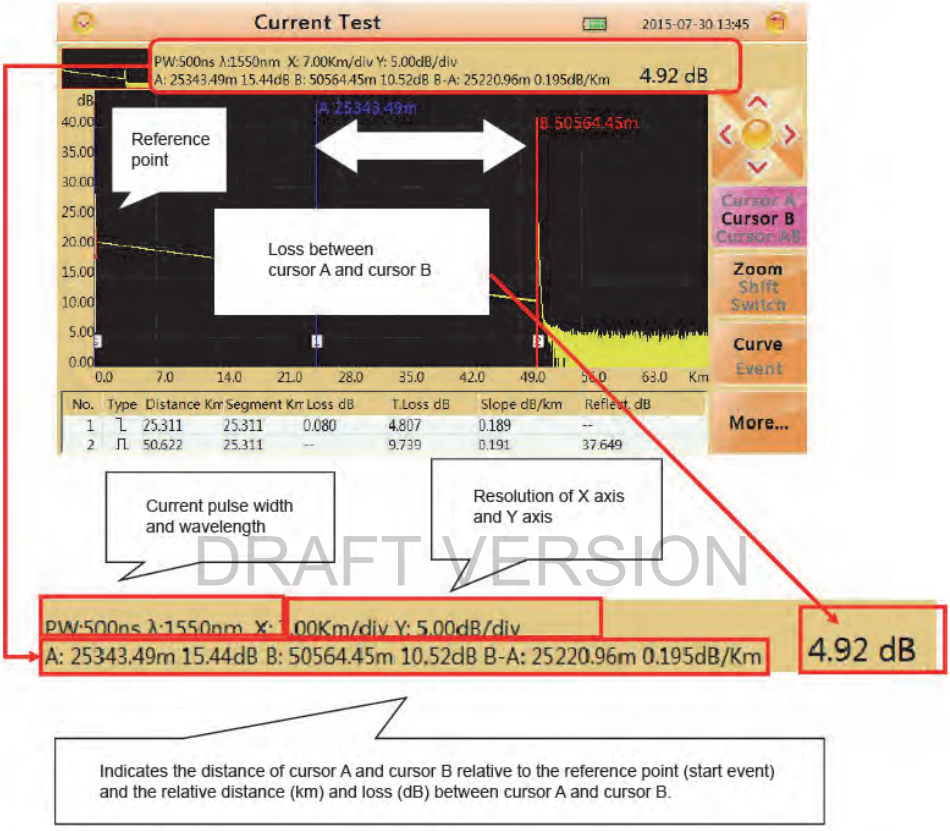



*Figure 25: Overview of displayed values of distance measurement*

### OTDR optimizing tool


*Figure 26: Guide fibre*

Guide Fibre:

Use a guide fibre to figure out the character of a connector. By adding this fibre you can move the first connector out of the blind area. In the same you can use this way to figure out the character of the last connector. The proper length of a guide fibre is 100 - 1000 m; it depends on the blind area of the OTDR. In theory, the minimum length of the guide fibre should be two times longer than the attenuation of the blind area, but it should be longer in practice.

**Setting proper parameters**



At the fist time using the OTDR, if you choose some testing parameter which is not suitable to the real condition may cause a bad result. You should take testing range, pulse width and wavelength into consideration.

Setting a proper testing range:

Testing range means maximum display range. This parameter will indicate how long the OTDR will display the range on its screen. This range must be longer than the testing fibre. Usually you may choose a range which is 20% longer.Take note that the testing range should not differ to much from the length of the testing fibre. Otherwise it will affect the effective resolution and an overlarge testing range will result in the generation of huge and useless amounts of data (see figure below).

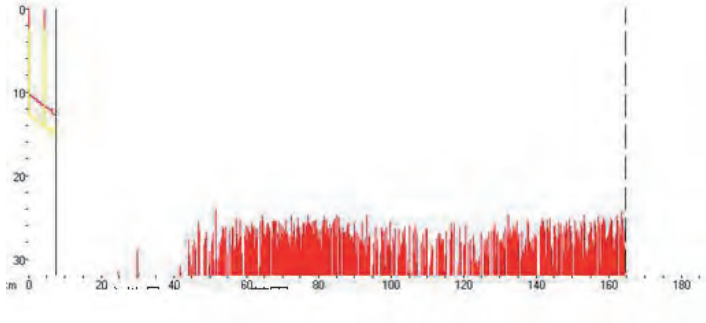



*Figure 27: Proper testing range*

Setting a proper pulse width:

Pulse width and blind area, dynamic range are directly related to the maximum length. In the picture below, ten different pulse width are used to test one testing fibre. The smallest pulse width results in the smallest blind area and the most terrible noise. The longest pulse width results in the smoothest curve and almost 1 km blind area.

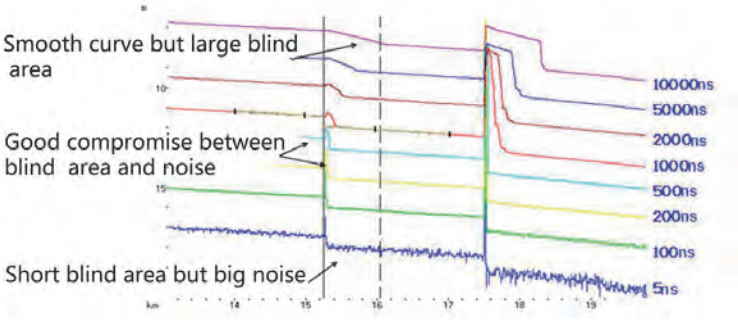



*Figure 28: Proper pulse width*



It is obviously at the top of the testing fibre influence on pulse width. In the chart below, we cannot detect the first connecting point located at 540 m by a large pulse width. When the pusle widht is decreased to 50 ns, this event can be detected.

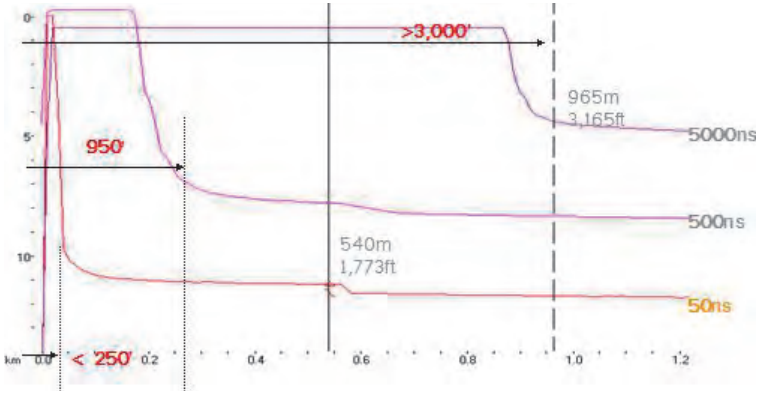



*Figure 28: Proper pulse width*

The dynamic range of measurement is determined by the selected pulse width. A narrow pulse width is more suitable to measure small distances, has less optical power and is not suitable for measuring larger distances. A wider pulse width delivers more optical power but is not suitable to detect events in the close-up range.

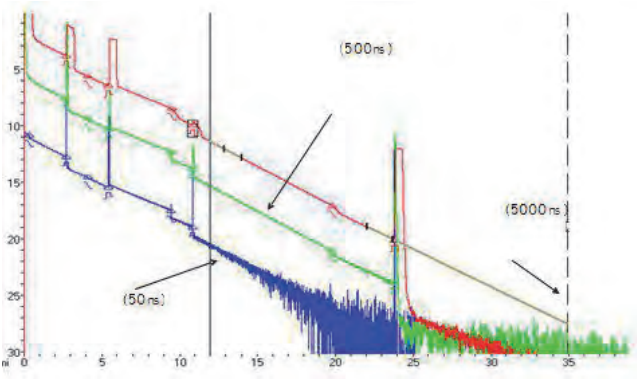



*Figure 29: Proper pulse width*



**Setting a proper wavelength**

Proceeding the test with the same fibre but different wavelength will lead to a different result. A longer testing wavelength is,more sensitive to bending. In the chart below the,first splicing point has a bending problem. Splicing loss value under 1550nm is bigger than that under 1310nm. The other points are similar with 1310 nm and 1550 nm. This phenomenon indicates that this fibre is just bended at the first point. If it's possible, please always compare the point state under 1310 nm and 1550 nm and judge whether it's bended or squashed.

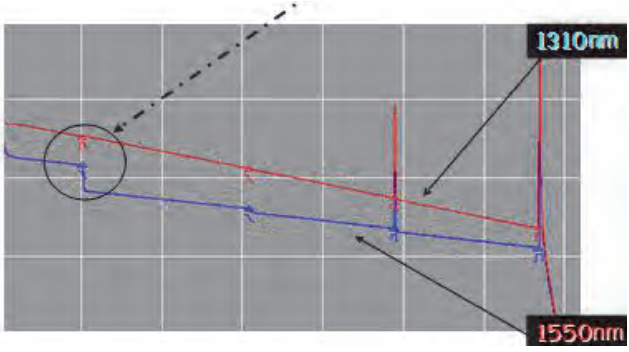



*Figure 30: Proper wavelength*

### Setting a proper test time

In averaging testing mode, a long testing time can reduce noise during the data sampling and improve precision to get a better and smoother curve.

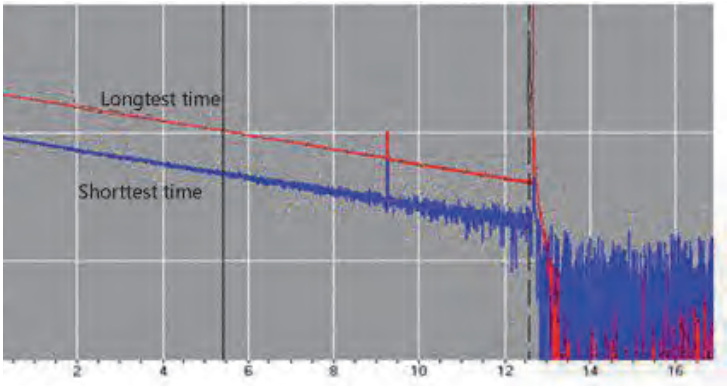



*Figure 31: Proper test time*

# Expanding the waveform and moving the display area

**Switching between event list and display window**

First press the „OTDR“ button on the start screen after switching on the device. You will now see the „Current Test" interface. Press the F3 button to switch between the “Curve” and “Event” display mode.

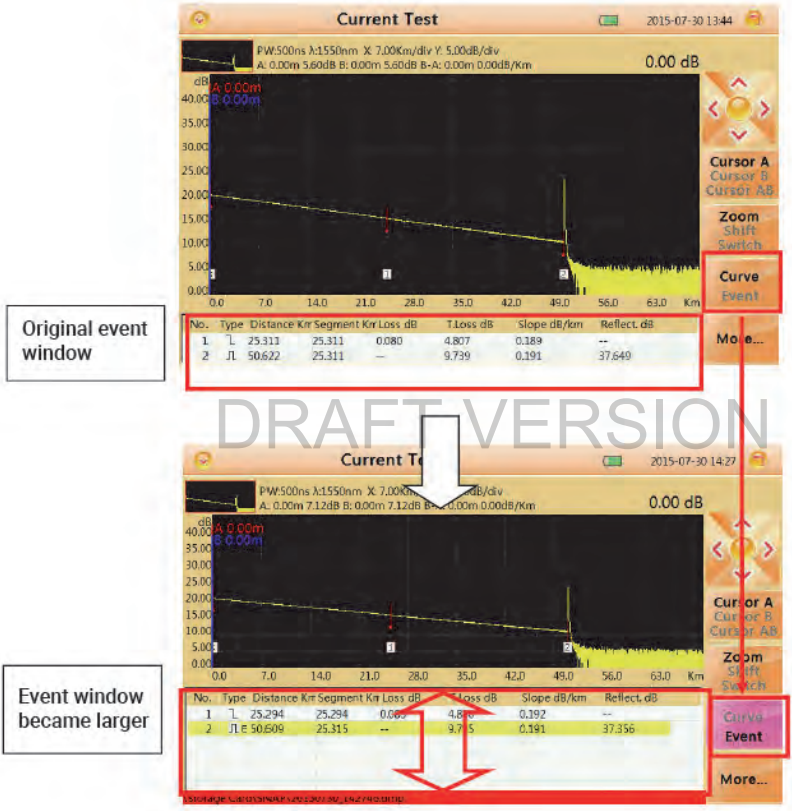





*Figure 32: Switching between event list and display window*

Use the arrow buttons on the control panel of the device to move from one entry in the event list to another. Every time you move from one selection in the event list to another, the cursor in the graph will move synchronously to the relevant event within the curve. You may press „Zoom","Move" and "Switch" button to adjust the curve to a better position. For more information please read the next sections.

The overview below describes the different items in the event list:

- `Type:` Type of event (attenuation event, reflection event or end event)
- `Distance:` Distance from start event to this event (km)
- `Segment:` Distance from this event to last event (km)
- `Loss:` Loss from this event Type of event (dB)
- `T.Loss:` Loss from start point to this event (dB)
- `Slope:` Ratio of loss (from last event to this event) to distance (from last event to this event)
- `Reflect:` Return loss of this event

**Cursor operation**

Activating the cursor:

Within the „Current Test“ screen, press the F1 button on the control panel of the device to activate the CURSOR function. The activated cursor in the submenu entry „Cursor“ turns yellow, which means it is active now.

Moving the cursor:

Use the arrow buttons to switch from cursor A to B, from B to AB and back to A.

**Curve operation**

Horizontal zoom:

Within the „Current Test“ screen, press the F1 button on the control panel of the device to activate the horizontal ZOOM function.

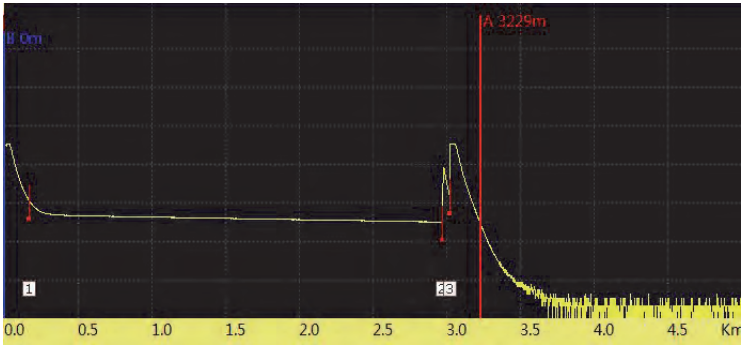



*Figure 33: Default display of the curve*



Use the arrow buttons to zoom in or out within the curve diagram.
To reset the display of the curve, press the OK button on the control panel of the device.

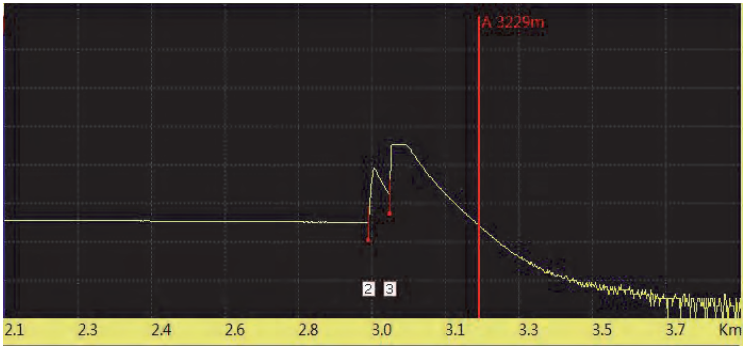



*Figure 34: Horizontally zoomed display of the curve*

Vertical zoom:

Within the „Current Test“ screen, press the F2 button on the control panel of the device to activate the vertical ZOOM function.

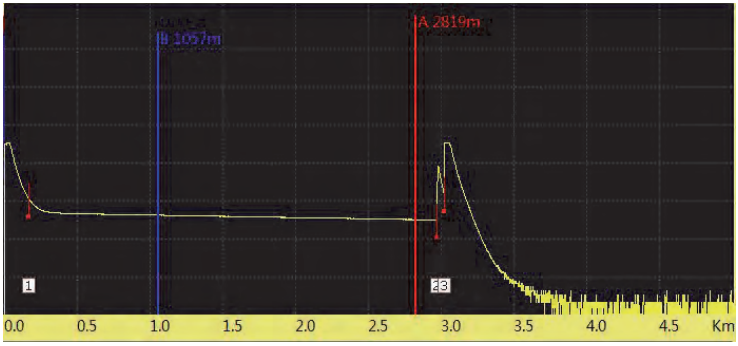



*Figure 35: Default display of the curve*

Use the arrow buttons to zoom in or out within the curve diagram.
To reset the display of the curve, press the OK button on the control panel of the device.



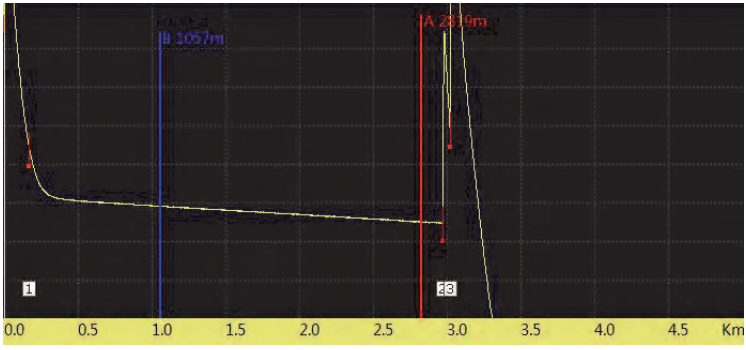



*Figure 36: Vertically zoomed display of the curve*

Horizontal and vertical shift:

Within the „Current Test“ screen, press the F2 button two times on the control panel of the device to activate the SHIFT function.

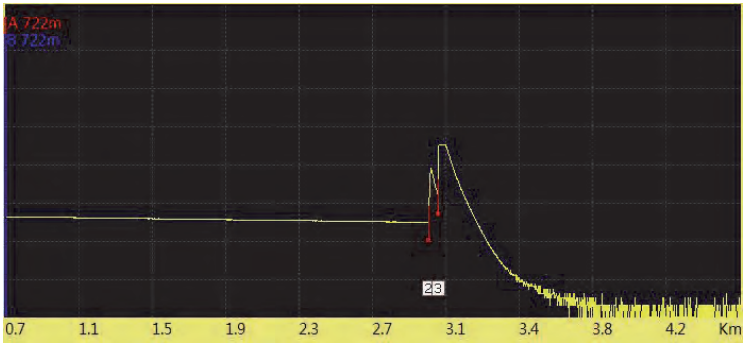



*Figure 37: Default display of the curve*

Use the arrow buttons to shift the curve diagram upwards, downwards, resp. to the left or right side. To reset the display of the curve, press the OK button on the control panel of the device.



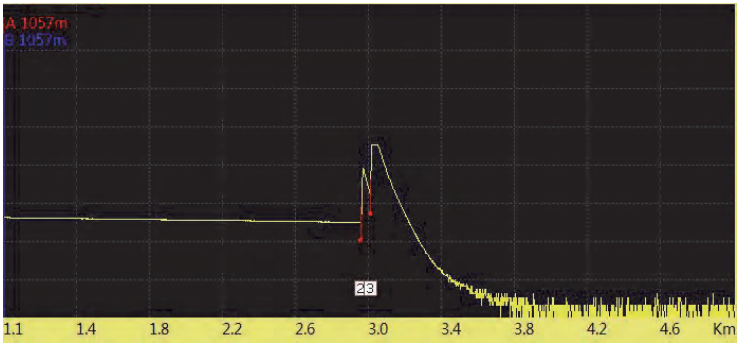



*Figure 38: Horizontally shifted display of the curve (example)*

### Elaborating an event

This section will explain how to elaborate an event on a curve as can be seen in the figure below (event 2).

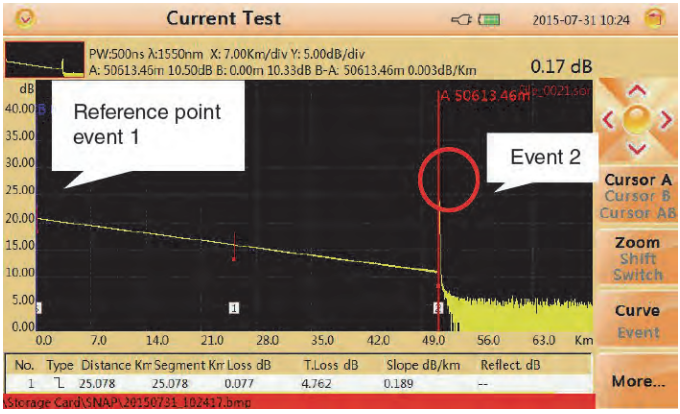



*Figure 39: elaborating an event on a curve*



Within the „Current Test“ screen, press the F1 button to activate the CURSOR function and use the arrow buttons to move the cursor to the left or to the right. Move to event 2.

Press the F2 button to activate the ZOOM function and use the right arrow button to zoom out of the event (cursor as the center).

Press the F2 button again to activate the SHIFT function and use the arrow buttons to shift the display of the curve to a proper position (see figure below).

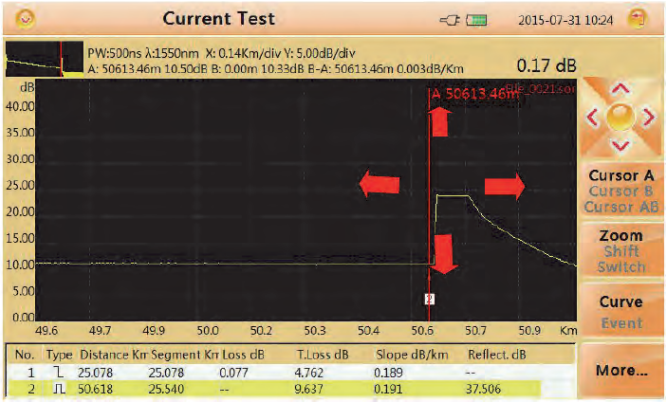



*Figure 40: curve shifted to a proper position*

### Switching between curves

You can display several curves and switch between them, while the current curve is shown in yellow. How to load several curves will be explained later in chapter „File Operation - Load a curve“.

Press the F2 button three times to acitvate the SWITCH function and use the arrow buttons to switch between curves (upper arrow switches to upper curve, lower arrow button switches to lower curve).

Press the OK button to reset all curves.

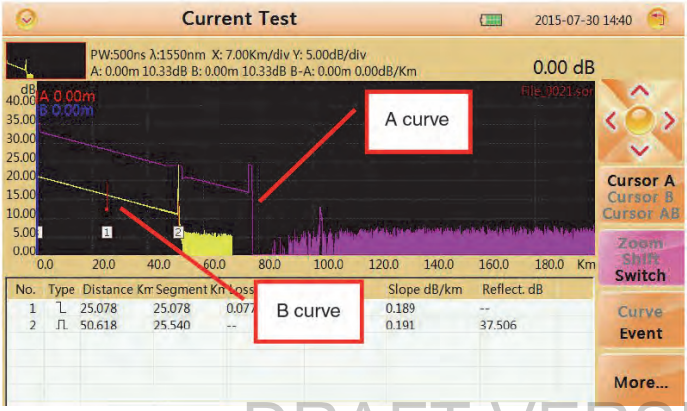





*Figure 41: two curves displayed*

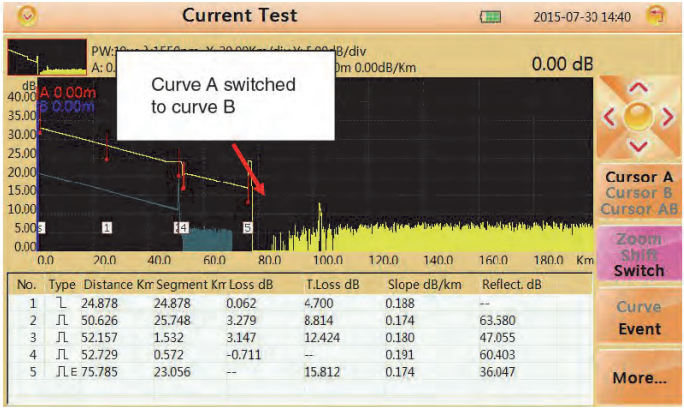



*Figure 42: current display switched to curve B*

***HINWEIS:*** *Don‘t display more than 8 curves at a time. If you load more than 8 curves, the last one will overwrite the first one.*

### Removing curves

You can remove one or several curves at a time.
Press the F4 button to activate the MORE menu.
Select „Remove Current Trace“ to remove the curve that is currently selected.
Select „Remove Other Trace“ to remove curves that are not currently selected.
Select „Remove All“ to remove all curves.

### Removing an event

Within the „Current Test“ screen press the F1 button to activate the cursor and move it to the target event.
Press the F4 button to select the MORE menu.
Select „Remove Event“ to remove the event.

### Adding an event

Within the „Current Test“ screen press the F1 button to activate the cursor and move it to the target event.
Press the F4 button to select the MORE menu.
Select „Add Event“ to add an event.

*HINWEIS: Event addition may not operate successfully for events that are too close to each other. You may move the cursor a bit away and have another try.*

# File Operation

Within the „Current Test“ screen press the FILE button on the control panel of the device. You should now see the file operation interface (see figure below):

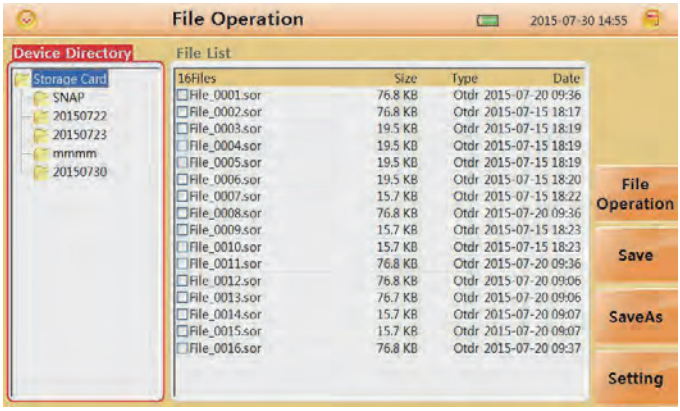



*Figure 43: File operation interface*



**Saving a curve**

Within the „Device Directory“ section choose the upper or lower arrow key to select a folder and press the OK button.
Then press the F1 button to enter the FILE OPERATION interface.

Press the „Save“ button on the screen to save the current curve under a default name set in „File Name Type“ under „File Setting“.

If you want to change the name of the file before saving, press the „Save as“ button on the screen to input the desired name. How you can input a desired name is explained in chapter „entering characters“

**Loading curves**

Within the „Device Directory“ section choose the upper or lower arrow key to select a folder and press the OK button.
Press the right arrow key to move to the „File List“ window.

Use the upper and lower arrow button to select the relevant curve file and press OK.

Press F1 to load the curve.

**Deleting curves**

Within the „Device Directory“ section choose the upper or lower arrow key to select a folder and press the OK button.
Press the right arrow key to move to the „File List“ window.
Then press the F1 button to enter the FILE OPERATION interface.
Select the curve file you want to delete.

Select „delete“ within the submenu to delete the curve file.

**Copying and moving curve files**

Within the „Device Directory“ section choose the upper or lower arrow key to select a folder and press the OK button.
Press the right arrow key to move to the „File List“ window.
Then press the F1 button to enter the FILE OPERATION interface.
Select the curve file you want to copy or move.

Select „cut“ or „copy“ within the submenu to copy or move the curve file.

Choose the target folder and press F1 to enter the FILE OPERATION interface.
Select „paste“ within the submenu to finish the operation.

## File setting

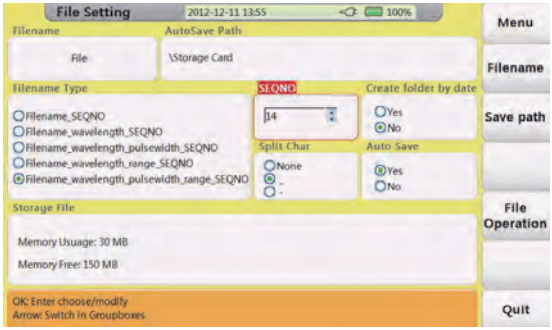



*Figure 44: File setting*

The following submenu entries can be selected:

- `Menu:` back to main menu
- `Filename:` modify prefix of filename
- `Save path:` modify the save path of files
- `File Operation:` back to file operation interface
- `Quit:` quit current interface



The following parameters can be adjusted:

- `Filename:` prefix of file name; can be modified in „Filename“ menu
- `Autosave Path:` adjust path for auto saving
- `Filename Type:` way of naming in auto save mode
- `SEQNO:` sequence number of next test and auto increment after each test
- `Create folder by date:` set create folder by today‘s date and save files seperately into them
- `Spli char:` set the type of separator
- `Auto save:` set auto save

### Print screen

The device can capture the current screen and save it as a file in .bmp format.

Press the screen symbol button on the control panel of the device.
You can then check the captured screen by pressing the FILE button on the control panel. The save path can be changed within the „File Setting“ menu.

# Entering characters

You can enter file names and comments from the character input screen shown below when saving the measured waveforms.

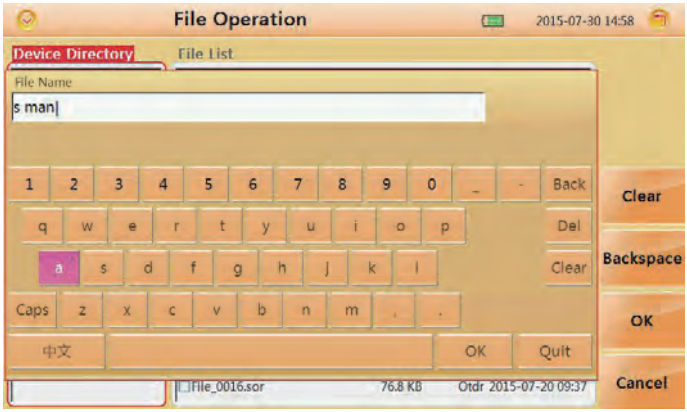



*Figure 45: Entering characters*



**Renaming**

Press the FILE button on the control panel of the device to open the „File Operation“ interface.
Within the „Device Directory“ section choose the upper or lower arrow key to select a folder and press the OK button.
Press the right arrow key to move to the „File List“ window. Select a file and choose „Rename“ from the submenu.
Input the desired name and confirm by pressing the OK button on the screen keyboard.

**Creating a directory**

Press the FILE button on the control panel of the device to open the „File Operation“ interface.
Within the „Device Directory“ section choose the upper or lower arrow key to select a root directory.

Choose „Create Directory“ from the submenu. Input the desired name and press the OK button on the screen keyboard.

# FLM Test

FLM Test (Fibre Link Measurement), also known as "Optical Eye", uses multiple pulse width acquisitions and advanced algorithms to quickly characterize the fibre under test and display the optical events applying intuitive symbols.


*Figure 46: FLM Test*



Select „FLM“ on the start screen to enter the FLM interface as shown below:

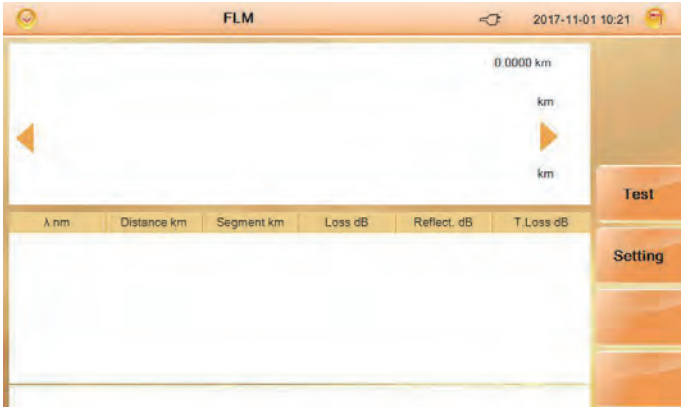



*Figure 47: FLM interface*

Press the F2 button to enter the setup interface.

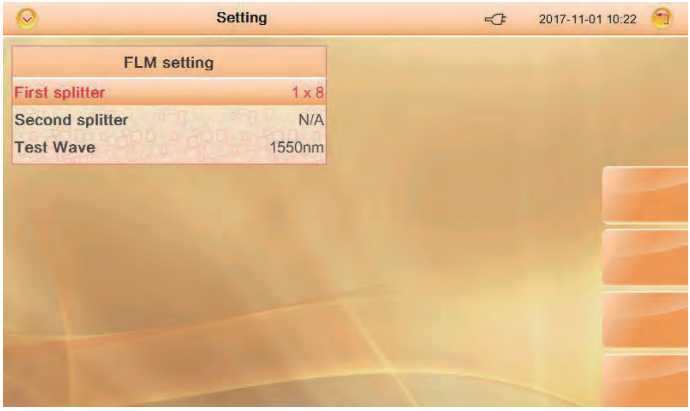



*Figure 48: Setup interface*

Use the upper and lower arrow key to select „First splitter“, „Second splitter“ or „Test Wave“ according to the actual condition of your test fibre.

After the setup is finished, press the ESC button on the control panel of the device and then press the F1 button to start the FLM test.



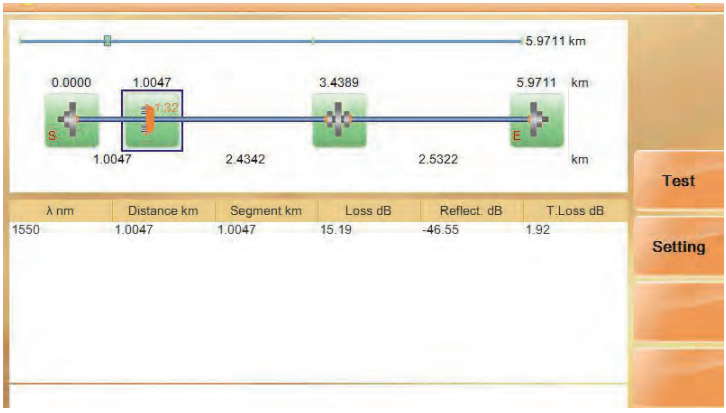



*Figure 49: FLM test*

Use the left and right arrow button to check detailed information of each event.

# VFL (Visual Fault Locator) module (optional)

The AOTDR is equipped with a VFL module (650 nm) to easily detect a broken point of an optical network. To launch the VFL module, press the VFL button on the start screen.

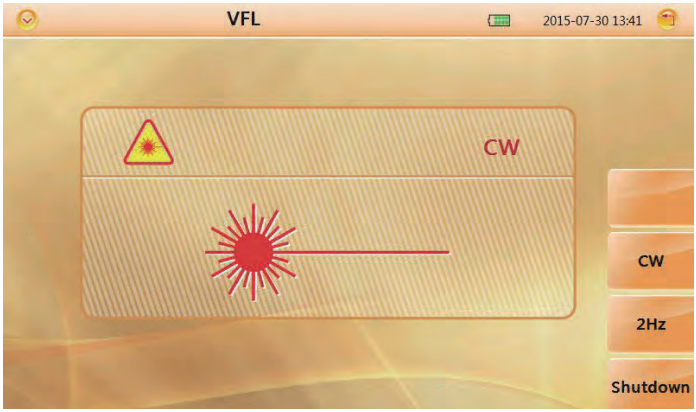



*Figure 50: VFL module*



The VFL module has two modes:

- `CW`: launches a continuous wave (650 nm)
- `2Hz`: launches a 2 Hz modulated wave (650 nm)

Press the ESC button on the control panel of the device to quit the VFL interface.

***HINWEIS:*** *Don't direct the optical port of the device or any fibre that isn't free of optical radiation to the human eye! If the eyes are exposed to optical radiation which is above the acceptable maximum, this could cause permanent damage to the eye.*

# Optical power meter module (optional)

The OPM module is used to quickly get the power of a terminal port at site.


*Figure 51: Optical power meter*



The following functions are available:

- `Setting:` set the offset value and display precision
- `λ:` switch the wavelength
- `Common λ Recog:` switch between common mode and wavelength detection mode

***HINWEIS:*** *The wavelength will not change automatically in common mode!*

# Background information on measurements

## Viewing the optical pulse measurement waveform

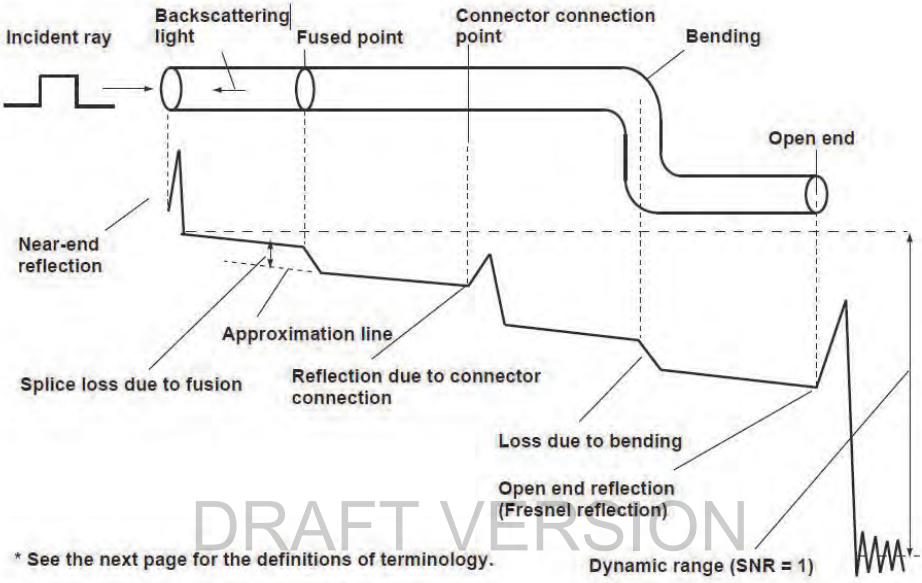





*Figure 54: Terminology*

### Terminology

- `Near-end reflection:` A reflection occurs in the gap between the AOTDR and the connector for the optical fibre cable. Losses and reflections of the connection points cannot be detected in the section. This section is called a dead zone.
- `Back scattering light:` When light travels through the optical fibre cable, a phenomenon called „Rayleigh Scattering“ occurs due to the nonuniformity of the density or constituents of materials smaller than the wavelength unit. The scattered light that is transmitted opposite to the direction of travel is called back scattering light.
- `Splice loss due to fusion:` A splice loss occurs at the fused section mainly due to axis offset and angle offset.
- `Reflection due to connector connection:` Unlike the fused section, a slight gap occurs in the connection section of connectors. Because the group refraction index changes in this gap, a reflection occurs causing a loss.

- `Fresnell reflection at the far end of the optical fibre:` Fresnel reflection occurs at the location where the optical fibre cable is broken or a location where the group refraction index changes such as the far end of the cable (glass and air) when light enters the cable. If the end face of the optical fibre cable is vertical, approximately 3,4 % (–14,7 dB) of the incident light power is reflected.
- `Dynamic range:` Dynamic range refers to the difference between the back scattering light level at the near end and the noise (RMS = 1).
- `Dead zone:` The locations where measurements cannot be made due to the effects of Fresnel reflection, connection points, etc.

# Maintenance and repair

## Tipps

The AOTDR uses a rechargable Li-ion battery. Please pay attention to the following:

- ☐ Keep the device dry and clean. Store it at room temperature (15 - 30 °C).
- ☐ Charge it monthly if you don't use it for a long time (more than once a month).
- ☐ Keep the optical port clean by using alcohol soaked cotton and recover the dust cap after use.
- ☐ Clean the optical port and the other connectors at a fixed period.

Follow the principles below before cleaning:

*HINWEIS: Disable laser launching before cleaning!*
*Any operations contrary to the instructions may result in dangerous laser injuries.*
*When the instrument is in operation, please always avoid looking directly into optic output. Although laser radiation is invisible, it may do serious injury to eyesight!*
*Be cautious of electric shock and make sure AC power is disconnected from the instrument before cleaning. Always use dry or moist soft cloth to clean the outside of the instrument, and never touch inside.*



## Cleaning tools

- ☐ Optical fibre cleaner (for cleaning of optical connectors)
- ☐ Optical fibre cleaning rod (for cleaning of optical inputs)
- ☐ Optical fibre cleaning tissue (for cleaning optical interfaces)
- ☐ Isopropyl alcohol
- ☐ Cotton ball
- ☐ Paper tissue
- ☐ Cleaning brush

**Cleaning of the optical port**

1. Screw down the cap.
2. Pull out the ceramic core with your fingers.
3. Clean the port carefully.
4. Recover the ceramic core.
5. Screw on the cap.

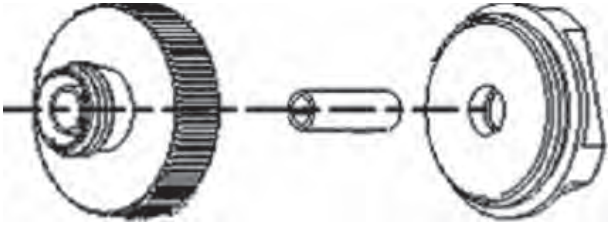


*Figure 55: structure of the optical port*

*HINWEIS: Be careful! Don't use tools like a plier; it may cause permanent damage to the optical port!*



- ☐ Shut off the device before cleaning.
- ☐ Keep the optical port clean by using alcohol soaked cotton and recover the dust cap after use.

**Calibration**

We suggest to calibrate the AOTDR twice a year. For more information please contact us**.**

## Repair

*ACHTUNG: The following safety information must be observed when performing maintenance and repair work. Failure to observe this safety information may result in personal injury due to electrical and thermal dangers!*

- ☐ The operating display only shows whether the DC current, which supplies the device components, has been disconnected from the mains voltage. If the operating display (for the power supply unit or the device) does not light up, this does not mean that the device has been fully disconnected from the mains voltage. There may still be voltages in the device that are dangerous to touch. You may therefore not open the device.
- ☐ The cover for the power supply unit is designed to prevent accidental contact with voltages that are dangerous to touch, and must not be removed.
- ☐ Read carefully: EN 60728 - Part 1 Safety requirements: No service work during thunderstorms.
- ☐ A defective device may only be repaired by the manufacturer to ensure that components with the original specification are used (e.g. power cable, fuse). Improperly performed repairs may result in considerable dangers for the user or installer. If malfunctions occur, the device must therefore be disconnected from the mains and authorised experts must be consulted. The device may need to be sent to the manufacturer.



Service tasks

***HINWEIS:*** *The device must only be operated with the original power supply unit!*

# Troubleshooting

If the device is not functioning correctly, please perform the following checks:

| Fault | Reason | Solution |
|---|---|---|
| Device can't be turned on. | 1. Holding time on power button is not enough (> 2 s).<br>2. Run out of power / battery has broken.<br>3. No battery inserted.<br>4. Too cold environment. | 1. Long press the ON/OFF key.<br>2. Connect external power / Replace a new battery.<br>3. Install a battery.<br>4. Change to another environment. |
| Display shows nearly nothing after the device is turned on. | 1. Brightness needs to be adjusted.<br>2. Connection between display and motherboard is not good. | 1. Adjust brightness.<br>2. Contact the customer service. |
| Battery does not work properly. | 1. Temperature is too high.<br>2. Connection is not proper.<br>3. Battery is nearly broken. | 1. Try to decrease the temperature.<br>2. Reconnect the battery.<br>3. Replace a new one. |
| Power state indicator turns yellow. | Battery is broken. | Replace a new one. |
| Measuring graphic only has front end reflection. | Connector is loose, polluted, damaged or unmatched. | Clean and reconnect. |
| No response | | Restart |
| Find Ghost | Common ghost caused by continuous reflection of connector. | Reconnect fault point of reflection event and reduce reflection strength. |



If the problem cannot be resolved, please contact the ASTRO customer service.

# Technical data

| Type | | AOTDR-26-VFL-FC-PM |
|---|---|---|
| Order number | | 212 204 |
| EAN-Code | | 4026187210403 |
| Wavelength | [nm] | 1310 / 1550 |
| Dynamic range | [dB] | 26 |
| Connector | | FC |
| Visual fault locator | | yes |
| Power meter | | yes |
| Pulse width | | 3 nm, 5 nm, 10 nm, 20 nm, 50 nm, 100 nm, 200 nm, 500 nm, 1µs, 2µs, 5µs, 10 µs, 20 µs |
| Sampling resolution | [m] | min. 0,05 |
| Sampling points | | max. 128.000 |
| Linearity | [dB/dB] | ± 0,03 |
| Loss threshold | [dB] | 0,01 |
| Loss resolution | [dB] | 0,001 |
| Distance resolution | [m] | 0,01 |
| IOR | | 1,2000 ~ 1,7000 |
| Distance accuracy | | ± 1 m + test distance * 3 * $10^{-5}$ + sampling resolution (excluding IOR uncertainty) |
| Memory capacity | | 80000 groups curve |
| VFL | | 10 mW, CW/2 Hz |
| OPM | [nm] | Calibrated wavelength: 850 / 1300 / 1310 / 1490 / 1550 / 1625 / 1650 test range -60 ~ +5 dBm |
| Interface | | 3x USB port (2x type A, 1x micro USB |
| Display | [inch] | 5, touch screen |
| Battery | | 7,4 V / 3300 mAh, lithium battery, continuous work 6 h (backlight off) |
| Ambient temperature | [°C] | -10 - +50 (operation), -20 - +70 (storage) |
| Dimensions | [mm] | 195 x 141 x 44 |
| Weight | [kg] | 0,9 (with battery) |
| Accessories | | Power adapter, charge cord. Lithium battery, FC adapter, USB cable, quick guide, test report, CD, carrying bag, wrist strap |
| Optional | | SC/LC adapter, launch cable box |

DRAFT VERSION

ASTRO Strobel Kommunikationssysteme GmbH



These operating instructions have been written by:
ASTRO Bit GmbH
Olefant 3, D-51427 Bergisch Gladbach (Bensberg) Germany
Phone: +49 2204/405-0, Fax: +49 2204/405-10
eMail: kontakt@astro-kom.de
Internet: www.astro-kom.de