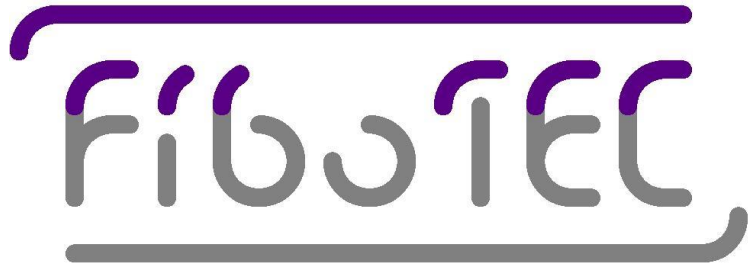


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Instruction Manual

Optical Fiber Fault Locator Module

FTIL T11 14100 M01

(Version 2.4 March 2004)

Safety precautions

This manual contains a description of controls, adjustments and procedures for normal operation of the Fault Locator Module. The Fault Locator should only be operated by qualified personnel who reviewed this manual before installing and applying the module.

CAUTION: Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

LASER SAFETY: This product contains laser diodes of class 1M. To ensure continued safety, do not remove any covers or attempt to gain access to the inside of the product.

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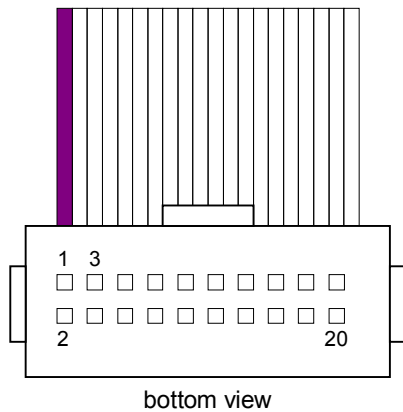
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Introduction

This manual describes the principle, the communications interface and the operation of the FTIL TI1 14100 M01 Optical Fiber Fault Locator Module. The communications interface is designed to work with a simple serial ASCII terminal or any PC with a serial port and terminal software on the basis of sending and receiving ASCII commands. All operational features of the module described in this manual are accessible in this way. Additional software for graphically presenting measurement results or a graphical user interface for the Fault Locator Module is available separately and is not described in this manual.

1. Installation

- The module should be mounted on a flat surface by means of four M3 screws. Ensure that the operating temperature range of the module is guaranteed during operation.
- Pin description supply voltage / controls connector:



- 1 - 2: V_{CC} (7.5 - 12 V dc stabilized)
- 3 - 4: gnd
- 18: μ C hardware reset ($R_{in} = 100 \Omega$)
- 19: RxD RS-232 Receive Data
- 20: TxD RS-232 Transmit Data
- 5 - 17: unused, connect to gnd

- Because the module includes no on/off-switch, it enables laser emission as soon as the supply voltage is applied! The output power is limited to 6dBm, according to laser class 1M.
- Serial Interface initial settings: 9600 baud, 8N1, no handshake
- Pins 5 to 17 are unused. It is recommended to connect them to gnd.

2. Functional description

The FTIL TI1 14100 M01 Optical Fiber Fault Locator Module (hereafter referenced as **FL**) is a reflectometer to monitor the optical transmission quality of single-mode optical fibers up to 82km length. Pulse sequences are sent down the fiber and back-reflected signals are detected and analysed by strength and distance. Any reflective discontinuity can be identified at a resolution up to 1.25m. Such discontinuities are caused by connectors, breaks and many other types of flaws in the fiber material, which contribute to a reduced optical transmission quality of the fiber network.

2.1 Optical time domain reflectometry

In a standard optical time domain reflectometer (OTDR) high-energy pulses of nsec duration are sent down the fiber. Measuring the time delay between the emitted pulse and detected back-reflexes and knowing the speed of light (i.e. the refractive index) in the fiber allows for a calculation of the distance of the reflective discontinuities down the fiber.

The FL is based on the principle of correlation OTDR. Here a continuous stream of low-power pulses at a cycle frequency of kHz to several MHz is sent down the fiber. The pulse stream comprises of digital pseudo-random numbers, number "0" corresponds to a low laser power level and number "1" corresponds to a high laser power level. The back-reflected stream of pulses is digitised and cross-correlated with a time-delayed version of the transmitted digital pseudo random number stream. A high degree of correlation at specific delays allows for a calculation of the distance of the reflective discontinuities down the fiber, if the speed of light (i.e. the refractive index) in the fiber is known.

The advantage of correlation OTDR compared to standard OTDR lies in a better signal-to-noise factor when integrating the reflected signal over a fixed amount of time. Additionally there is no need for a high-power pulsed laser source, so the reflectometer can be operated at laser safety class 1M at any desired wavelength, including CWDM and DWDM channel wavelengths.

2.2 Building blocks of the Fault Locator Module

Figure 1 shows the building blocks of the FL.

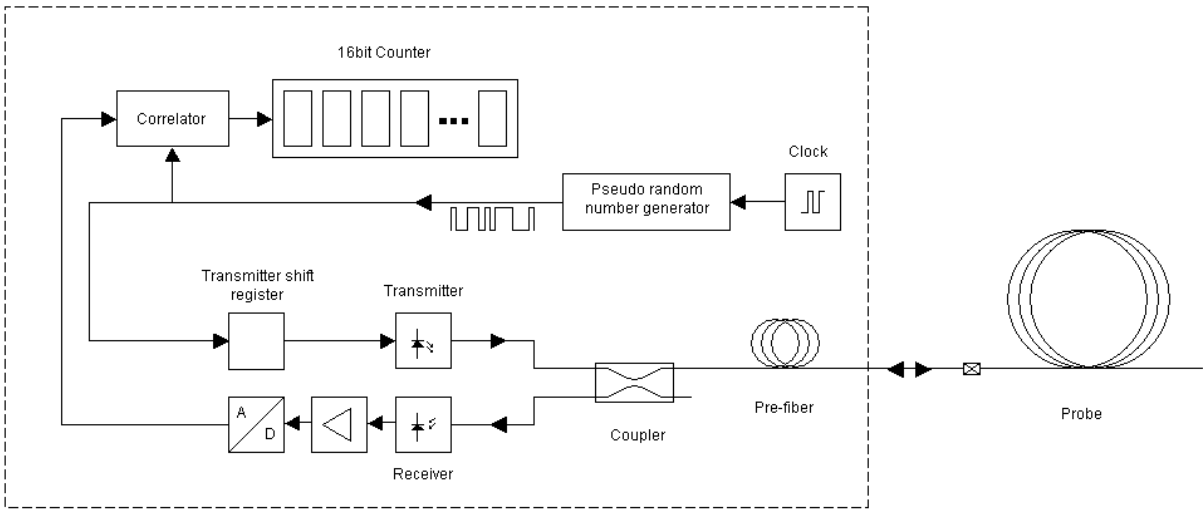


Figure 1

A digital pseudo random numbers generator sends a continuous stream of states "0" and "1" at a user-selectable clock rate (kHz to MHz). The states modulate the power of a laser diode (transmitter) which is connected to the fiber network (probe) via a 50%/50% directional coupler. Reflections from the fiber enter the same coupler. A digital correlator is responsible for delaying the sent data stream and cross-correlating it with the digitised reflected signal stream. The result is fed into 256 up/down counters of 16 bit length (15 bit plus sign). Each counter integrates the correlation of the stream at one cycle additional time delay. For example counter 5 shows signal correlation, if the reflected data stream from the fiber correlates to the transmitted data stream sent 5 cycles ago. This corresponds to reflective events within $4.5 \cdot (\text{cycle time}/2) / c$ and $5.5 \cdot (\text{cycle time}/2) / c$ meters down the fiber, with c =speed of light in the fiber. The resolution equals cycle-time divided by a factor of two, because the light has to travel down the fiber to the reflective event, and then back again to the FL. If several events in several counters are detected, the numbers in the counters directly relate to the strengths of the reflective events. Reflection signals don't get lost, if the network is measured at low spatial resolution, i.e. at low cycle-time. If a resolution of e.g. 160 meters is chosen, all events within each 160 meters slot are integrated in the corresponding counter. Then a particular slot can be chosen by pre-delaying the transmitted data stream with the transmitter shift register. After the resolution has been increased to 20 meters, it can be checked, how many different events are hidden within the previous 160 meters slot. The 20 meters slots can be checked again at higher resolution, and so on.

The FL includes 25 meters of optical fiber directly attached behind the coupler. This pre-fiber is intended to be used for spatial calibration, if the refractive index of the probe fiber is unknown.

2.3 Fault Locator Module measurement process

The FL integrates the correlation values in the 256 up/down counters until an overflow (counter value \$FFFF or \$0000) occurs. Then the user needs to read-out all counter values, to reset the counters (value \$8000) and to start integration again.

The counter values are signed (value \$8000 corresponds to zero), because the noise can generate negative correlation values during integration. With a perfectly absorbing probe connected to the FL, all counter values will be equally distributed around value \$8000 during a measurement.

In theory infinite low reflective events can be detected, only limited by the time the user is willed to wait for the overflow to occur or by stopping integration manually. On the other hand there is no information available about the absolute strength of the reflective event, which caused the overflow. As mentioned above, different signals in different counters can be linearly related in strength to each other. So absolute reflection strength numbers can be generated, if one of the signals in the counters is a signal from a reflection reference introduced into the fiber network.

If a strong reflection dominates others and causes an overflow before the weaker reflections can build up in the counters, the corresponding counter can be disabled. In this case the strongest of the remaining reflections will cause an overflow. By continuing this process several times with several reflection signals it is possible to measure events of lower and lower signal strength and to take advantage of the theoretically infinite sensitivity of the measurement principle.

2.4 Special features of correlation OTDR measurement data

Two effects are limiting the theoretically infinite sensitivity of the measurement principle in practice. One effect is caused by the finite amplification bandwidth of the optical-to-electrical interface behind the optical receiver. The other effect results from the quality of the auto-correlation of the pseudo random numbers used. Minimizing both effects in correlation OTDR measurements is still under development.

Any deviation from infinite bandwidth in the transmitter chain electronics of the signals from the fiber to the correlator results in a characteristic deformation of the correlation signal from a delta-peak. As a consequence one sharp reflection can cause counts in many subsequent counters. Another consequence are “anti-correlations” – i.e. regions of negative counter values – appearing behind a reflective peak, since the deformation resembles a ringing structure. Even with dc-coupled amplifiers bandwidth limitations are present, caused by automatic gain control or automatic offset correction feedback loops in the kHz and Hz range in the amplifier ICs.

Pseudo random numbers generated by linear congruential generators or feedback shift registers possess particular high-order auto-correlation characteristics. These characteristics are manifesting itself in the up/down counters as reflective “ghosts” of positive or negative sign. They cannot be removed by averaging the correlation signal. Their appearance is connected to the reflections in the fiber network and to the selected resolution.

3. Programming, serial interface commands

The Fault Locator Module is controlled by a RS-232 serial interface. Any serial ASCII terminal or any PC with a serial port and terminal software can be used to operate the FL. All operational features of the module described in this manual are accessible in this way.

3.1 Command structure

The FL is controlled by sending simple commands based on the ASCII character set. Except for one command's response all responses of the FL are based on the ASCII character set. Several commands produce no response at all. In case of misspelling such a command or in case of using an unknown command, an error message ("Sorry?") is the response.

Every command is represented either by a single word, two words separated by a space or one word and a number separated by a space. Do not omit the space. All letters of a word are lowercase letters. Numbers are hexadecimal and either two digits (\$00-\$FF) or four digits (\$0000-\$FFFF) in length and either upper or lowercase letters. Do not omit leading zeroes, i.e. type "000A" instead of "A".

A colon at the beginning of a new line indicates, that the FL is ready to receive a command. During typing of a command typing errors can be corrected by using the backspace key (ASCII code \$08). Commands are sent to the FL by typing the carriage return key (ASCII code \$0D).

3.2 Tutorial: Operating the Fault Locator Module from an ASCII terminal

Set the terminal software to 9600 baud and 8N1. After power-on reset the FL will send a "hello message" including the version number of its firmware. Receiving the hello message confirms that the reset was successful and that serial communication works well. The command **help** prints out a list of all available commands. Change the serial baud rate by typing **baud XXXX** with XXXX = baud rate in hexadecimal, e.g. sending **baud 9600** increases the baud rate to 38400. The maximum baud rate depends on the type and length of cable used.

After power-on reset the FL will immediately start correlating and modifying the 256 up/down counters from their initial values \$8000. You can check individual counter values by the command **rch XX** with XX = channel number \$00 to \$FF. The response is a hexadecimal number in the range \$0000 to \$FFFF. Successive channels can be viewed by sending **rchn XX** with XX = the highest channel, e.g. **rchn 10** sends 16 lines of hexadecimal numbers, the values of the counters \$10 down to \$00. If an external software is used to communicate with the FL, the command **rchnb XX** can be used to receive the counter values in binary format.

If one of the counters experiences an overflow (values \$0000 or \$FFFF encountered) then the FL stops correlation. The state of the FL (running or halted) can be tested by the command **readovfl**. Response \$01 reads as running and response \$00 reads that an overflow occurred and the correlation is halted. Reading counter values via **rch XX** or **rchn XX** is always possible independent of the state of the FL being halted or running.

Counter values are initialized to \$8000 and the FL correlating is restarted by the command **preload**. To get an immediate information as soon as a counter overflow is experienced, the FL can be set to a state of "sending asynchronous messages permitted". After power-on reset sending asynchronous messages is not permitted, i.e. the FL is only sending data via the serial interface as a direct response to a command. The command **amsmsg on** permits the FL to send data as a response to internal events like error messages or to send the word "ovfl" in case of counter overflow experienced.

The horizontal resolution slot of each up/down counter directly corresponds to the frequency of the clock generating the pseudo random numbers. The maximum clock rate is 80 MHz. Assuming a fiber refractive index of $n=1.5$ the cycle time of $1/80\text{MHz} = 12.5 \text{ nsec}$ leads to a resolution slot of approx. 1.25 meters for each counter. The resolution is half the length of a cycle, because the light has to travel down the fiber to the reflective event, and then back again to the FL. The clock frequency can be reduced by a factor of $2 \cdot x$ with $x = 01$ to $7F$ ($x = 7F$ after power-up reset of the FL) and a factor of 1 with $x = 00$. This is achieved by the command **resfac XX** with $XX = 00$ to $7F$. To e.g. get an overview of the complete probe fiber network, type **resfac 7F** and thus measure the network at approx. 320 meters resolution. Keep in mind that the exact resolution value depends on the fiber refractive index.

A typical start of a measurement session looks like this:

```
:hello           ; test of the serial interface
:baud 9600       ; baud rate change to 38400 baud
:hello           ; checking serial interface again
:resfac 7F       ; maximum horizontal resolution (approx. 320 m)
:amsg on        ; permit asynchronous messages

:preload         ; start correlation and wait for async message "ovfl"
:rchnb FF       ; -> "overflow" experienced, thus read the correlation result
:preload
:rchnb FF       ; etc.
```

In case of the external software can't handle async messages, the session looks like this:

```
:hello           ; test of the serial interface
:baud 9600       ; baud rate change to 38400 baud
:hello           ; checking serial interface again
:resfac 7F       ; maximum horizontal resolution (approx. 320 m)

:preload         ; start correlation and wait for async message "overflow"
:readovfl       ; check for FL halted
:readovfl
...
:rchnb FF       ; -> "ovfl" experienced, thus read the correlation result

:preload
:readovfl
:readovfl
...
:rchnb FF       ; etc.
```

If a strongly absorbing probe fiber is attached to the FL, it might take quite a long time (several to tenth of seconds) before a counter overflow is experienced. The command **cnt off** is used to halt the FL correlation manually. After this use **cnt on** to manually restart correlation.

If a strong reflection dominates the measurement, the corresponding counter can be disabled from producing the overflow via the command **choff XX** with $XX =$ counter number. Now smaller reflections are enabled to grow during the correlation measurement in different counters and to produce overflow. The subsequent overflow counter can be disabled again, and so on. The command **chall** enables all counters again for normal operation of the FL.

To measure distant segments of a fiber at high resolution, a transmitter shift register is used to pre-delay the pseudo random numbers. This register is loaded by the command **txcntfw XXXX** with $\$XXXX =$ number of clock cycles or counter channels. If a segment 10 km down the fiber should be measured at 20 meters resolution, choose **resfac 08** and **txcntfw 01F4**. The FL now starts

Correlator:

cnt on	Enable correlation and run up/down counters
cnt off	Stop correlation and stop up/down counters
chon XX	Enable counter \$XX to produce overflow
choff XX	Disable counter \$XX from producing overflow
chall	Enable all counters to produce overflow

Up/down counters:

preload	Preload all counters with value \$8000 and start correlation
rch XX	Display value of counter \$XX
rchn XX	Display values of counters \$XX to \$00
rchnb XX	Display values of counters \$XX to \$00 in binary format
readovfl	Show overflow status (00 = overflow experienced)

Transmitter shift register:

txcntfw XXXX	Forward transmitter shift register \$XXXX clock cycles
txcntres	Reset transmitter shift register to zero clock cycles

Random number generator clock:

resfac XX	Divide clock by 2*\$XX
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Serial interface:

hello	Display firmware version number
baud XXXX	Change baud rate to \$XXXX
echo on	Echo input characters
echo off	No echo of input characters
amsg on	Permit asynchronous output messages
amsg off	Prohibit asynchronous output messages

General commands:

help	Display list of commands
ophour	Display 1/10 operating hours of the FL

Analysis commands:

maxcnt	Display value and channel of counter with highest count
maxpk	Display level and channel of highest 'peak'
setminch XX	Set minimum cnt/peak search channel to \$XX

3.4 Alphabetical list of commands

Every command is represented either by a single word, two words separated by a space or one word and a number separated by a space. Do not omit the space. All letters of a word are lowercase letters. Numbers are hexadecimal and either two digits (\$00-\$FF) or four digits (\$0000-\$FFFF) in length and either upper or lowercase letters. Do not omit leading zeroes, i.e. type "000A" instead of "A".

The field "response" relates to output sent via the serial interface. Several commands produce no output, nonetheless the corresponding changes in the FL hardware are initiated.

The term "default" relates to the corresponding function enabled after power-up reset.

Command: **amsg off** (default)

Function:

Prohibit asynchronous message output via the serial interface. This might be the necessary state for an external communications software, if it cannot handle the FL sending data via the serial interface at times other than directly after a command.

Response: none

Command: **amsg on**

Function:

Permit asynchronous message output via the serial interface. Get immediate information about FL hardware conditions via the serial interface.

Response:

Error messages or "ovfl", if one of the up/down counters experiences an overflow (\$0000 or \$FFFF).

Command: **baud XXXX** (default XXXX = \$2580)

Function:

Change the baud rate to \$XXXX baud. Typical values are

9600 baud	\$2580
14400 baud	\$3840
19200 baud	\$4800
38400 baud	\$9600

Response: none

Command: **chall**

Function:

Enable all up/down counters to produce overflow.

Response: none

Command: **choff XX**

Function:

Disable up/down counter \$XX from producing overflow. Its value is now fixed at \$8000.

Response: none

Command: **chon XX**

Function:

Enable up/down counter \$XX to produce overflow.

Response: none

Command: **cnt off**

Function:

Stop correlation manually and stop up/down counters from changing its values. Continue counting with command 'cnt on'.

Response: none

Command: **cnt on** (default)

Function:

Enable correlation and run up/down counters. This command continues correlation, if it was manually stopped with 'cnt off'. Sending this command is not necessary after an overflow-stop of the counters. In this case use 'preload' to start a new measurement.

Response: "ovfl", if amsg on is enabled and overflow condition is experienced.

Command: **echo off**

Function:

Stop echoing input characters via the serial interface.

Response: none

Command: **echo on** (default)
Function:
Echo input characters via the serial interface.
Response: none

Command: **hello**
Function:
"Hello message". Check the serial interface by displaying the firmware version number
Response:
Several lines of ASCII character text.

Command: **help**
Function:
Display list of commands via serial interface.
Response:
Several lines of ASCII character text.

Command: **maxcnt**
Function:
Display value and channel of counter with highest count. The count search runs from counter channel XX to FF, with XX given by command **setminch XX**. The counter values are checked immediately after sending the command, correlation and counting is not affected by this command. If an overflow was experienced and the correlator isn't restarted again, the command remains displaying the same result.
Response:
A line with hex value YY, giving the counter number (\$00 to FF) and a subsequent line with hex value ZZZZ, giving the 16bit counter value.

Command: **maxpk**
Function:
Display height and channel position of highest 'peak' appearing along the 256 counters. A 'peak' is positively identified by the following condition: A counter with a value higher than the values of its predecesing and its succeeding counters. All 'peaks' are identified and the one with the highest value is displayed. The search runs from counter channel XX to FF, with XX given by command **setminch XX**. If no peak can be identified within the interval XX to FF, \$00 and \$0000 are displayed as height and channel position. The counter values are checked immediately after sending the command, correlation and counting is not affected by this command. If an overflow was experienced and the correlator isn't restarted again, the command remains displaying the same result. If a strong reflection is present and overflow status was experienced, commands **maxcnt** and **maxpk** usually give the same results. However, command **maxpk** is especially designed and recommended for peak search if no graphical representation of the counter values is available.
Response:
A line with hex value YY, giving the 'peak' position (\$00 to FF) and a subsequent line with hex value ZZZZ, giving the 16bit counter value. YY=\$00, ZZZZ=\$0000 indicates, that no peak was found within the channel interval specified by command **setminch XX**.

Command: **ophour**
Function:
Display 1/10 operating hours of the FL
Response:
A line with value YYYY displaying the operating hours of the FL in units of 6 minutes.

Command: **preload**
Function:
Preloads all up/down counters with value \$8000 and starts correlation.
Response: "ovfl", if amsg on is enabled and overflow condition is experienced.

Command: **rch XX**

Function:

Display value of up/down counter \$XX. Correlation and counting is not affected by this command.

Response:

A line with hex value YYYY.

Command: **rchn XX**

Function:

Display values of up/down counters \$XX to \$00. Correlation and counting is not affected by this command.

Response:

XX+1 lines with hex values YYYY.

Command: **rchnb XX**

Function:

Display values of up/down counters \$XX to \$00. Correlation and counting is not affected by this command. Same as **rchn XX** except for binary data output: each hex value YYYY is represented by a pair of 8bit bytes instead of two pairs of 7bit ASCII characters.

Response:

One line with 2*(XX+1) bytes of 8bit binary data (no pairs of 7bit ASCII characters). Do not use this command if working on an ASCII terminal, since generic output might be produced.

Command: **readovfl**

Function:

Show overflow status of the up/down counters. 00 = overflow experienced. 01 = FL still correlating. If external software allows for async messages, better enable the 'amsq on' status and wait for the FL to signalize an "ovfl".

Response:

A line with hex number 00 or 01.

Command: **resfac XX** (default XX = 7F)

Function:

Divide pseudo random numbers clock by 2*XX with XX = 01 to 7F. No clock division at XX = 00. Clock rate is 80 MHz. The corresponding horizontal resolution is depending on the fiber refractive index. With n=1.5 X=00 relates to approx. 1.25m resolution and XX = 7F to approx. 320 m resolution.

Response: none

Command: **setminch XX** (default XX = 00)

Function:

Set minimum search channel number to \$XX and thus define the channel search interval for the commands **maxcnt** and **maxpk** ranging from channel \$XX to \$FF.

Response: none

Command: **txcntfw XXXX** (default XXXX = 0000)

Function:

Forward transmitter shift register by \$XXXX clock cycles. This command can be executed repeatedly to achieve multiple offsets of 65535. Example: If a segment 100 km down the fiber should be measured at 1.25 meters resolution, choose **resfac 00** and **txcntfw FFFF + txcntfw 3881**.

Response: none

Command: **txcntres**

Function:

Reset transmitter shift register to zero clock cycles.

Response: none

3.5 Error messages

If a command is misspelled or if an unknown command is sent, the FL responds by sending a single line reading "Sorry?". Other error messages should not occur during normal operation. If the FL sends the "Hello message" without a previous hello command typed, this indicates a soft reset by the firmware. It should not occur during normal operation. Please contact our service personnel in case of such event taking place repeatedly.

4. Operation

The operation of the Fault Locator Module is described using the following optical fiber network as an example:

A first fiber coil of 14.5 km length and 20 dB attenuation and a second coil of 6.6 km length and 10 dB attenuation are used. Both coils are connected via FC/PC connectors and the second coil is terminated by an open FC/PC connector. The attenuation of the coils in dB/km is chosen very high (nearly 10 times higher than usually) to demonstrate the high dynamic range of the Fault Locator Module.

Results of the measurements are presented graphically; the conversion of counter channels to distance in the graphs is done by external software and not by the FL.

IMPORTANT:

Take care that the optical connector of the FL is not only free from solid particles (dust, dirt) but also free from transparent greasy films like fingerprints. Such films will cause very high reflections and will blind the FL. It is recommended to periodically clean the connector end face with alcohol, acetone, etc. Using a standard reel tape connector cleaner (like a Cletop cassette) might not be sufficient!!

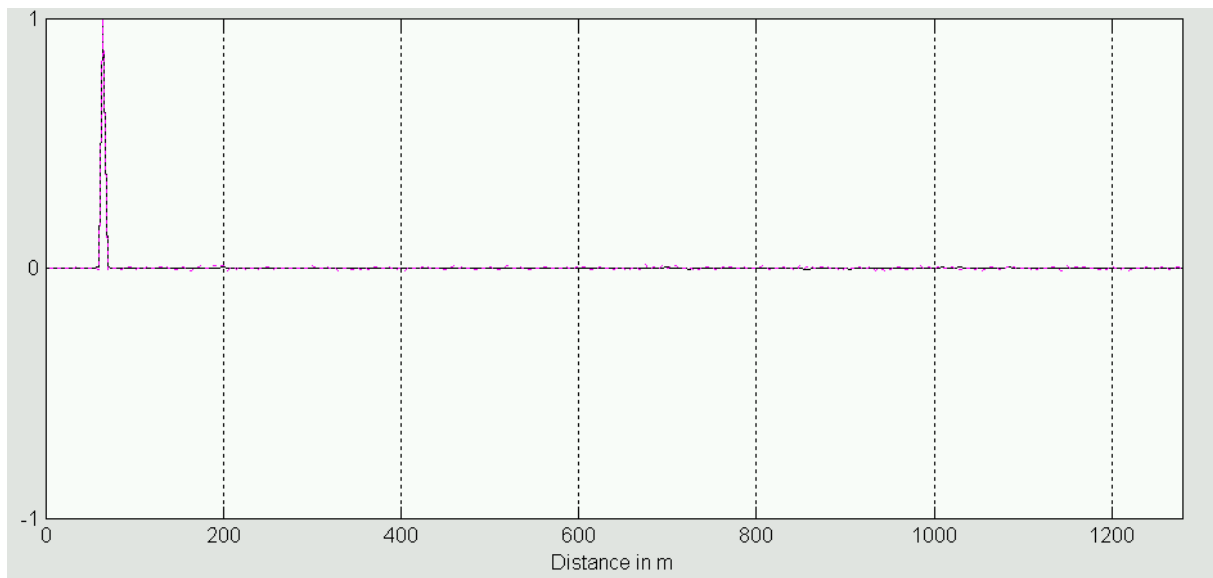


Figure 3: Resolution 5m, 20 times averaged

Figure 3 shows a high-resolution measurement of the FL without a fiber connected to the module. The single reflex results from the open FC/APC connector 52 meters behind the internal 50%/50% coupler. It can be recognized that the display software is not applying an accurate refractive index value of the fiber, because the 52 meters peak appears at a slightly farther distance.

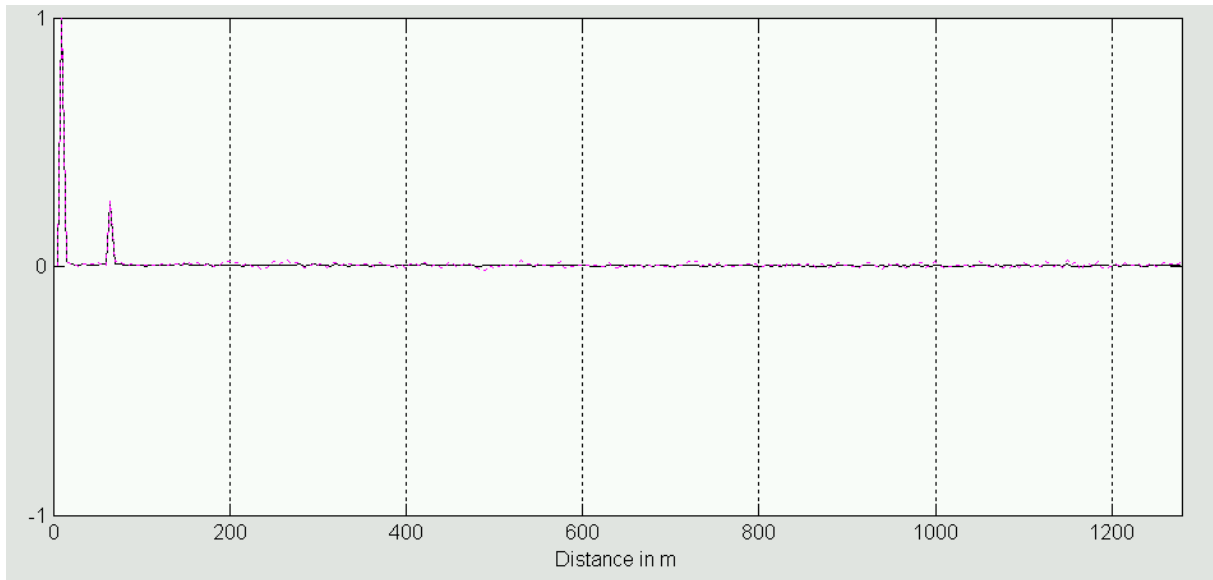


Figure 4: Resolution 5m, 20 times averaged

In figure 4 the FL is connected to the probe fiber network described above. Now the FC/APC adaptor reflectivity is strongly reduced compared to the open end situation. Typical reflectivity values for FC/APC adaptors are -60 to -70 dB, much lower than the -14 dB reflectivity of an open end FC/PC connector. Consequently the residual reflectivity of the internal FL coupler can be seen now.

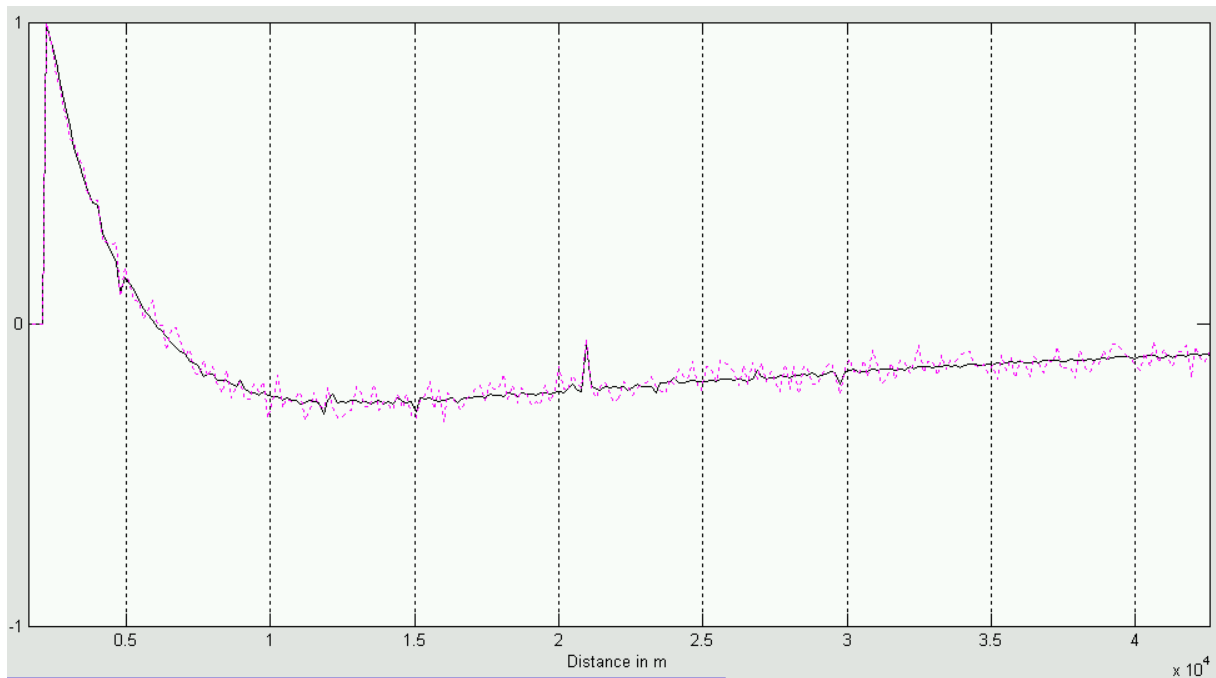


Figure 5: Resolution 160m, 50 times averaged, Counters 1-5 disabled

Figure 5 shows the complete network (14.5 plus 6.6 km fiber length) connected to the FL. The counters 1 to 5 are disabled to prevent the excessive Rayleigh-scattering from superimposing the reflex of the connector at the fiber end. This reflex is rather low: Fiber attenuation is 30 dB and the glass reflection is approx. 14 dB (4%), so the signal of the laser transmitter is reduced by 74 dB before entering the internal coupler of the FL again. Due to the effects discussed in chapter 2.4 the correlation signals falls below zero behind the Rayleigh-scattering and some small positive and negative ghosts are visible as well.

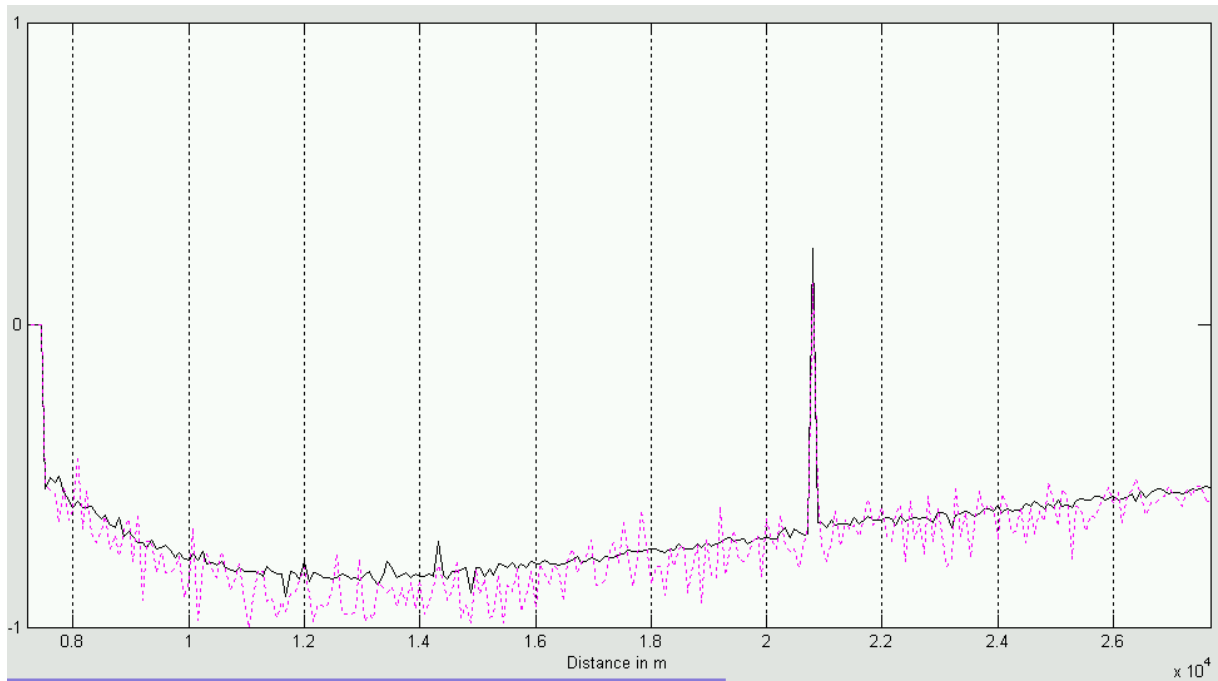


Figure 6: Resolution 80m, 50 times averaged, counters 1-5 disabled, offset

Figure 6 shows the situation of figure 5 with higher resolution and with offset from the strong Rayleigh signal. Now the FC/PC adaptor between the two coils at km 14.5 can be identified.

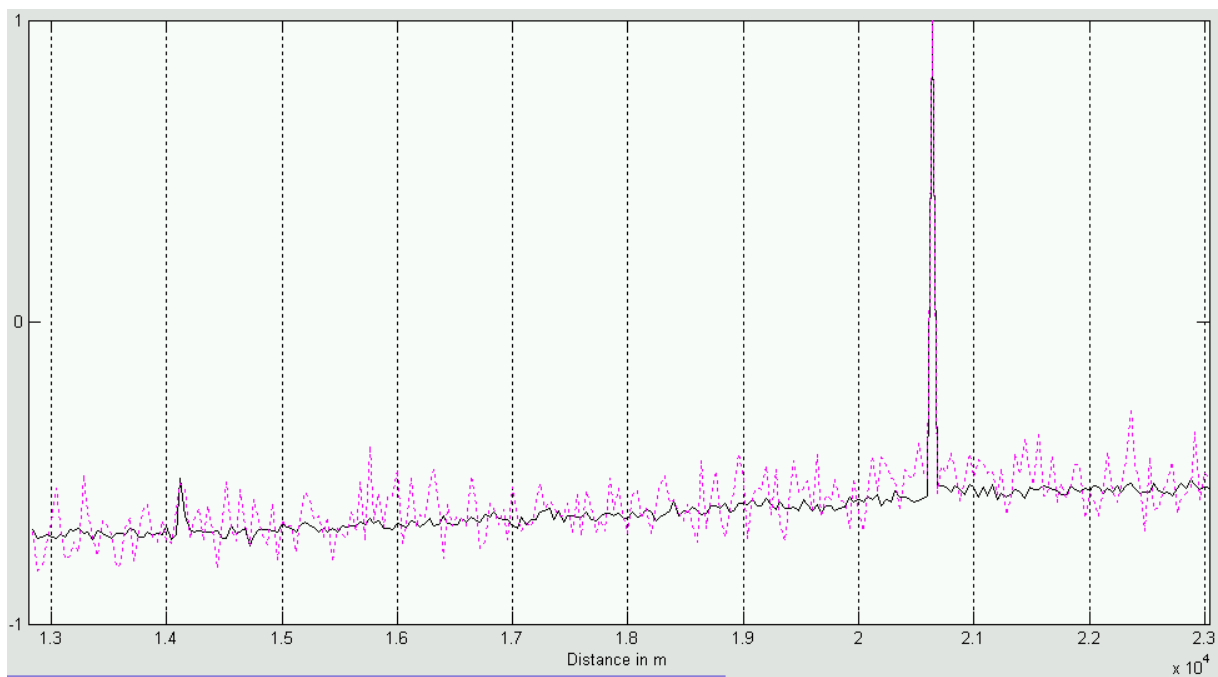


Figure 7: Resolution 40m, 50 times averaged, offset

To distinguish the adaptor peak at 14.5 km from ghosts, in figure 7 the offset has been advanced further and the resolution has been increased.

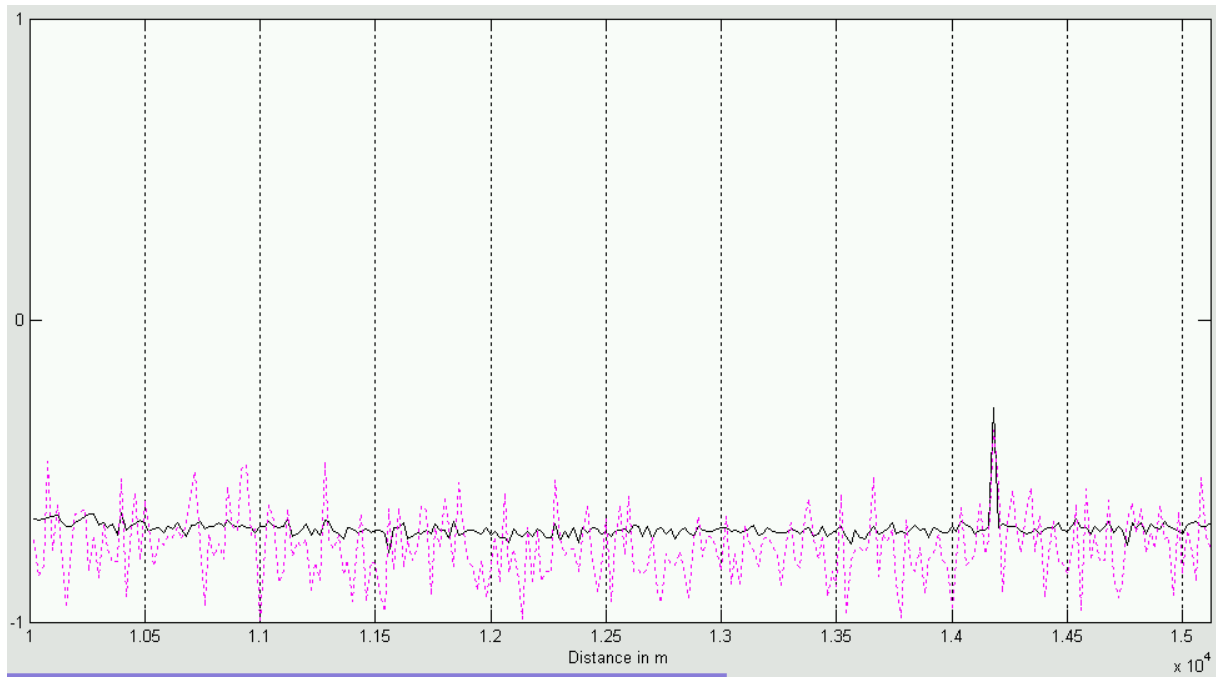


Figure 8: Resolution 20m, 50 times averaged, offset

Figure 8 shows the 14 km adaptor peak at even higher resolution.

5. Technical Specifications

Power supply

Supply voltage	7.5 - 12 V dc stabilized
Supply current	< 0.7 A

Optical specifications

Laser safety class	1M
Output power	< 6dBm
Wavelength	1544.54 nm (ITU channel 41)
Optical connector	FC/APC
Internal fiber length	25 m

Horizontal specifications

Fundamental frequency	80.000000 MHz
Sampling points	256
Sampling resolution	1.25 to 320 m (@ n=1.5) in 128 steps
Distance ranges	0.32 to 82 km (@ n=1.5) in 128 steps
Maximum distance offset	1374389535 km (9 AU)
Distance accuracy	>10 ⁻⁴ of sampling resolution

Vertical specifications

Dynamic range per meas.	45.1 dB
Full dynamic range	> 100 dB

Others

Module size	150x100x17 mm
Operating temp. range	0 – 40 °C (non-condensing)
Storage temp. range	-40 – 85 °C