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Design of the Control System for the Opening of the Access Chambers for Fiber Optic Networks

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Abstract The article deals with the design of a system that would allow to control the opening of the access chambers for fiber optic networks. The absence of metallic elements in the optical fiber does not allow the usage of conventional sensors working on metallic element. This led to proposition of the control system that operates on the principle of signal changes in the optical fiber caused by bending.

Keywords: *optical fibers, access chamber*

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1. Introduction

The operational principle of the control system is based on the change of the optical signal caused by micobending and macrobending of the fiber and the reflected signal attenuation [1,2,3]. The proposed system would detect signal attenuation in optical fiber due to its macrobending that would arise when the access chamber is open.

We have proposed a mechanism that would ensure that in closed access chamber the optical fiber would be embedded directly, without considerable loss of the signal. After opening of the access chamber a flexible part of the mechanism would cause macrobending of a fiber, thus causing signal attenuation. Subsequently, the attenuation would be recorded. Since the properties of optical fibers, resulting in their greater susceptibility to macrobending at higher wavelengths, the system would work with a wavelength of 1550 nm. Figure 1 shows a design of the mechanism.

2. Test of the Designed Control System

Designed and produced sensor was tested in the laboratory, on the simulated optical path with model of the access chamber. For this purpose was used smaller scale model of a plastic access chamber which is being used to cover the optical coupling in all types of networks [4,5]. The model was made of the same material as the real chambers are being produced, and the model´s dimensions 400x250x150 mm accounted for about one-third the size of the real chamber. As a cover was used plastic cover with dimensions 420x250x40 mm. Into this model was placed the testing sensor (Figure 2) [6,7].

As a monitoring device was used universal measuring platform EXFO FTB200, which has two slots into which can be fitted up to 11 different modules (Figure 3). Depending on the selected module, it is possible to make a CWDM measurement by analyzer SONET/SDH, routing parameters measurement OTDR and Ethernet testing from 10 Mbit/s to 10 Gbit/s.

For measurement of the parameters of single-mode optic fiber is used OTDR module FTB-7400 (Figure 4). OTDR (Optical Time Domain Reflectometer) is the baseline measurement of optical fiber and in practice most commonly used. It works on the principle of reflection of test signal to various inhomogeneities, plug connectors, welds and the ends of the fibers in the transition to another setting.

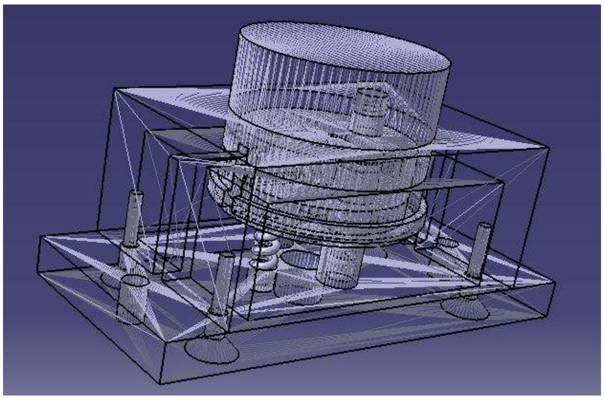

Figure 1. Design of the mechanical part of the control system

Figure 2. The plastic model of the access chamber for optical fibers

Figure 3. Measurement device EXFO FTB 200

Figure 4. Module OTDR FTB-7400E

The OTDR module FTB-7400 has a high dynamic range of up to 42 db for long-haul testing, event dead zone of 0.8 m and attenuation dead zone of 4 m, making it suitable for measurements in all types of network (long-haul, metropolitan and access) [8,9].

The sensor was placed into the model of access chamber in the pressed position when the chamber was closed and when the chamber was open, the sensor was released (Figure 5). The complete test setup is shown in Figure 6.

Figure 5. Placement of the sensor in the model of access chamber

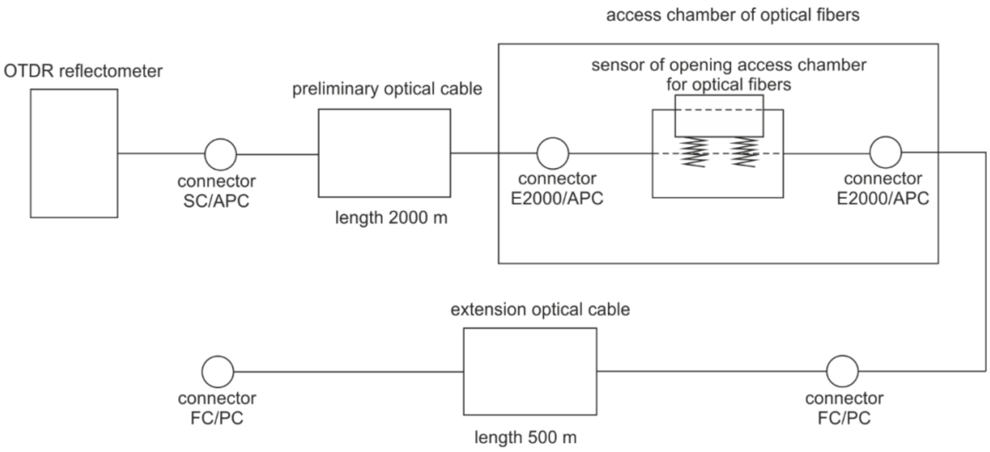

Figure 6. Schema of testing optical route

Within the testing of the functionality of the sensor two measurements were done. The first one was carried out in a "normal" state of the optical network, and thus in the closed access chamber. The second measurement was implemented at "fault" state, with open access chamber. Basic setup of the measuring instrument was identical for both measurements. The length of the optical path of the test was 2.512 kilometers, therefore was chosen a range of 3 km of the measuring instrument and the test signal pulse 100 ns. One measurement lasted 15 seconds, which is sufficient time to evaluate all inhomogeneities on the test route.

3. Evaluation of the Results of Test Measurements

General data of the test optical route, the measuring device and its settings, as well as on-site measurements are identical for both measurements. This information is shown in Figure 7.

OTDR Report

General Information

Filename:	2004m500mFiber01.trc	Cable ID:	DIP. PRACA
Test date:	21. 4. 2015	Fiber ID:	Fiber01
Test time:	20:42 (GMT+01:00)	Customer:	TUKE SjF
Job ID:		Company:	SITEL s.r.o
Comments:			

Location A / **Location B**

Location:	2004m	Location:	500m
Operator:	Andrejko Marek	Operator:	
Unit's model:	FTB-7400E-0234B-EA		
Unit's s/n:	733925		

Results

Span length:	2,5123 km	Average splice loss:	
Span loss:	1,298 dB	Maximum splice loss:	
Average loss:	0,517 dB/km	Span ORL:	< 19,19 dB

Test Parameters

Wavelength:	1550 nm (9 µm)	Duration:	15 s
Range:	3,0000 km	High resolution:	Yes
Pulse:	100 ns	Resolution:	0,159 m

Test Settings

IOR:	1,470000	Splice loss threshold:	0,020 dB
Backscatter:	-81,87 dB	Reflectance threshold:	-72,0 dB
Helix factor:	0,00 %	End-of-fiber threshold:	5,000 dB

Figure 7. General information about measurements

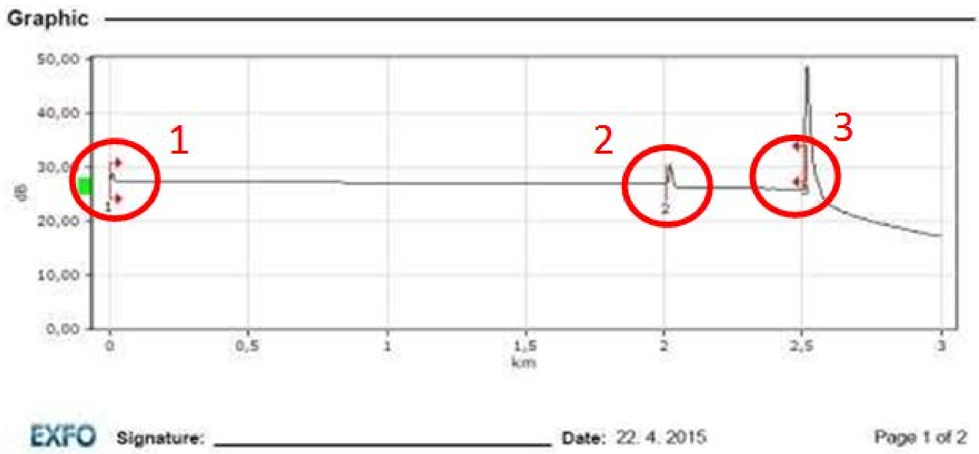

Figure 8. Graph of the signal in the test optical route with closed access chamber

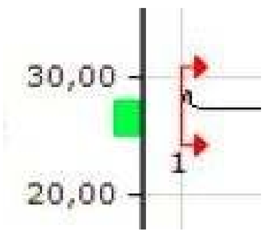

Figure 9. Event 1 - beginning of the optical path

Figure 8 shows the curve of the signal in the test optical route with closed access chamber. The progress shows the beginning of the optical path (1) (Figure 9), location of the sensor (2) (Figure 10) and the end of the optical route (3) (Figure 11). In the position of the sensor (2) the slight decrease of signal was recorded, an attenuation value at this point. Subtracting from the chart can be very difficult to determine the value of attenuation.

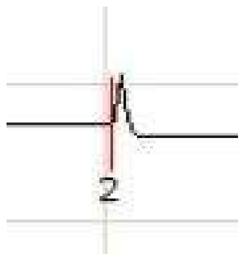

Figure 10. Event 2 -location of the sensor at closed access chamber

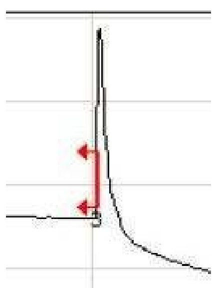

Figure 11. Event 3 - the end of the optical route

OTDR Report

Event Table

Type	Number	Location/Length (km)	Loss (dB)	Reflection (dB)	Attenuation (dB/km)	Cumul. (dB)
Launch Level	1	0,0000		-61,5		0,000
	Section	2,0099	0,376		0,187	0,376
Reflective Event	2	2,0099	0,817	-54,4		1,193
	Section	0,5024	0,105		0,209	1,298
Reflective Event	3	2,5123		-16,8		1,298

Markers Information

A:	0,9968 km	27,175 dB	B:	1,4964 km	27,064 dB
a:	0,4971 km	27,259 dB	b:	1,9961 km	26,984 dB
B-A:	0,4997 km	0,110 dB			

Manual Measurements

4-pt. ev. loss:	-0,001 dB	A-B LSA att.:	0,184 dB/km
A-B LSA loss:	0,092 dB	3-pt. reflectance:	*****
2-pt. sect. att.:	0,221 dB/km	A-B ORL:	45,09 dB

Figure 12. Report of events on the optical route with closed access chamber

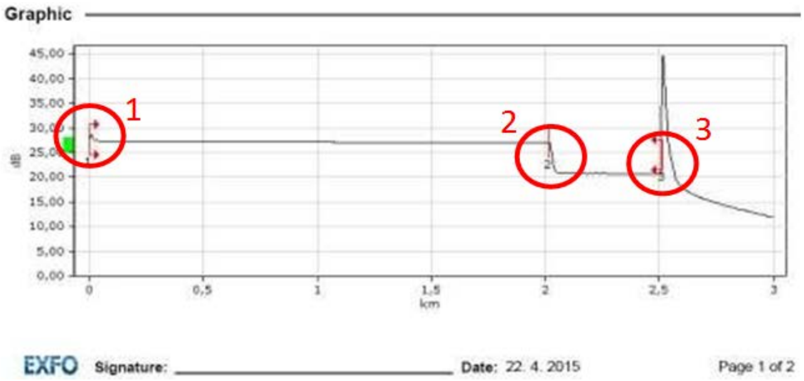

Figure 13. Graph of the signal in the test optical route with opened access chamber

Figure 12 shows the data from measurements of signal in the optical route with closed access chamber. There are information about the type of event, the place where this event occurred, the attenuation, reflection and loss of the signal since the beginning of the optical route. In our case the most important is the attenuation for the event No 2.

Figure 13 shows the curve of the signal in the test optical route with opened access chamber. Similar to the closed access chamber we can see the beginning of the optical path (1), location of the sensor (2) (Figure 14) and the end of the optical route (3). In the position of the sensor (2) the significant decline in the test signal was recorded, an attenuation value at this point. By subtracting from the chart it is possible to determine the attenuation value at this event.

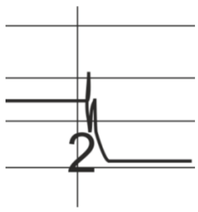

Figure 14. Event 2 -location of the sensor at opened access chamber

OTDR Report

Event Table

Type	Number	Location/Length (km)	Loss (dB)	Reflection (dB)	Attenuation (dB/km)	Cumul. (dB)
Launch Level	1	0,0000		-61,5		0,000
	Section	2,0138	0,378		0,187	0,378
Non-Reflective Event	2	2,0138	6,123			6,501
	Section	0,4984	0,116		0,232	6,616
Reflective Event	3	2,5121		-13,4		6,616

Markers Information

A:	0,9968 km	27,171 dB	B:	1,4964 km	27,069 dB
a:	0,4971 km	27,271 dB	b:	1,9961 km	26,971 dB
B-A:	0,4997 km	0,102 dB			

Manual Measurements

4-pt. ev. loss:	0,002 dB	A-B LSA att.:	0,181 dB/km
A-B LSA loss:	0,090 dB	3-pt. reflectance:	-74,8 dB
2-pt. sect. att.:	0,203 dB/km	A-B ORL:	45,09 dB

Figure 15. Report of events on the optical route with opened access chamber

As with the evaluation of measurements in a closed access chamber, evaluation program displays all events that occur in optical route in a transparent table which provides information on the type of event, the place where this event occurred, attenuation, reflection and loss of the signal since the beginning of the optical route (Figure 15).

4. Conclusions

Already the visual comparison of the graphs of the test signal indicates significant decrease of the signal at open access chamber in comparison to the signal at the closed access chamber. Comparison of the data from the tables Tab. 61 and Tab. 63 also shows the different values of signal attenuation and that confirms the functionality of the sensor for opening of the access chamber on the optical route. Signal attenuation value in the closed chamber is 0.817 db. Opening of the cover of the access chamber caused the change of the signal to 6.123 db.

Change in attenuation of 5.3 dB is large enough to be detected by monitoring equipment and evaluated as a failure. Such change is a warning for the competent person, that the access chamber was opened. Subsequently, optical network operator can send a technician to the location where the access chamber is placed and thus prevent the occurrence of faults in the optical route caused by improper foreign fault or vandalism.

Acknowledgements

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