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EVALUATION OF PON NETWORK WITH UTILIZATION FIBER G.652.B

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ABSTRACT

This article is devoted to the measurement and analysis of passive optical networks PON (Passive Optical Network) with and without utilization PLC (Planar Light wave Circuit) splitter. The real network simulation is done as a prevention of complications in the final construction of optical network, which is designed for specific user requirements. The article describes connections between two campuses. These buildings are connected by single mode fiber G.652.B (320 m) terminated with E2000 / APC and optical splitter (PLC) with the ratio of 1:8 and insertion loss of 10.8 dB.Main contribution of this paper was comparison of the difference between measured parameters of optical networks and demonstration when it is better to use an optical splitter, and when it is better to connect the fiber directly.

Keywords: OTDR, optical splitter, PLC, PON.

1. INTRODUCTION

In the last decade the optical communications systems became well discussed topic among domestic and foreign authors. The components of optical systems were theoretically analysed, and in practice effectively used particularly in the sphere of telecommunications. The use of optical fiber and sources of coherent light were a great motivation for many scientists to develop optical communication systems.

The optical fibers are nowadays considered as an efficient transmission medium designed to transmit a large amount of data over a long distance. Compared to other transmission media (e.g. a free space and copper cables) they have exceptional qualities [1-3]. The optical networks are divided by way of sharing used fibers and network termination units to point-to-point (P2P) and point-to-multipoint (P2MP) networks.

For the P2P optical networks is transmission path and each communication unit at the end side intended for one end user. For P2MP optical networks is part of the optical infrastructure including central communication units shared by a greater number of end users.

2. PASSIVE OPTICAL NETWORK

Passive Optical Network PON is one of the most important directions in the deployment of optical access networks. Therefore between the control panel of Internet service provider and the end customer is not required to use any powered active network elements such as the AON. PON networks are multi-point networks (Point to Multipoint), which means that to one central element is connected a large number of users (32-128), who will share a single transmission medium for access to required services.

On the whole transmission path are only passive optical elements that serve to divide the optical signal into all directions without amplification or modification of signal. In the downlink, the entire communication is from the central unit OLT (Optical Line Terminator) using the hub equally distributed to all connected users, regardless of for whom are data intended [4], [5]. The actual selection of data is transferred on the terminal equipment ONU (Optical Network Unit), or the end terminal ONT (Optical Network Termination).

On the user side are selected specific data from the accepted framework for a particular user and other data are discarded. Data transmitted from the OLT are coded therefore another user on the network could not read data that are not intended for him. The Figure-1 provides a scheme for PON architecture.

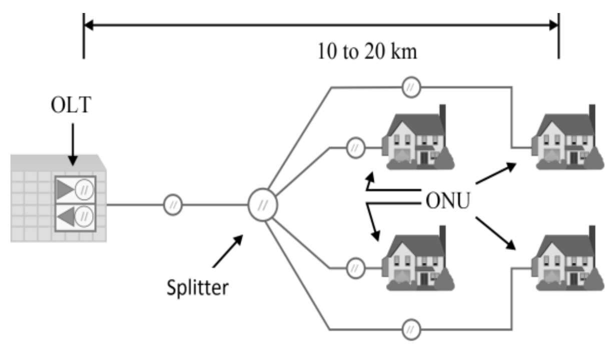

Figure-1. Scheme of the PON architecture.

The basic elements for the implementation of PON include:

A. ONT (Optical Network Termination)

Ending on the user side, which is responsible for the adaptation of protocols and their conversion interface between the user (or the local network) and optical access network. In this device is the end of an optical fiber network during the direct interconnection of the customer network with this device. NT (Network Termination) is used in telecommunications for the generic labelling of network termination, which is mostly localized on the user side.

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B. ONU (Optical Network Unit)

In this case, we are talking about a generalized version of the ONT, the end on the user side. The main difference, compare to the previous optical unit, is in its location in the hierarchy OAN and implementation of end-user connectivity using metallic or wireless network that immediately follows on the ONU device. The main difference can be seen in the number of connected users, which is in this case compare to ONT multiple. With the transition to a different type of signal on the interface transmission media is evident conversion of the optical signal into an electrical or radio, and vice versa.

C. OLT (Optical Link Termination)

Optical terminating unit is located on the provider side and is owned by Telecommunication Company. It is responsible for connection to backbone networks, used-protocol conversion and distribution of the management of clock signals [6-8]. Fundamental part of this activity is the management and supervision of individual terminal units ONT and ONU.

D. ODN (Optical Distribution Network)

It is constituted by all optical transmission means between units OLT, ONT and ONU. This area includes connecting and interfacing elements: optical fibers, connectors, couplers, filters, splitters elements: active or passive optical splitters, wavelength filters, multiplexers. The usual ODN topology is a star, a multistage star, a bus or a circle.

E. OAN (Optical Access Network)

Is a set of optical distribution networks ODN connected to one central node. The basic blocks of the OAN are in Figure-2.

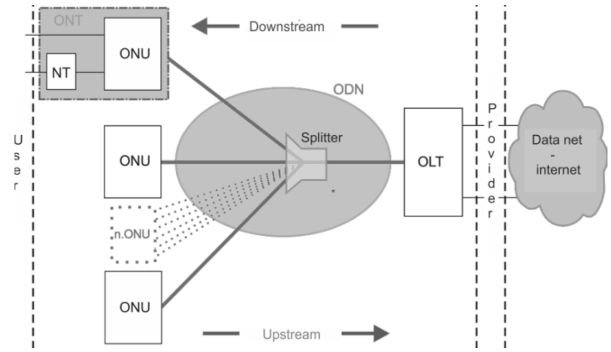

Figure-2. Scheme of elements OAN.

3. OPTICAL SPLITTER

The fiber splitter is a passive network element specifically designed for PON networks. In FTTH systems, which are operated in PON networks, are generally a two-way passive elements that have one input port and several output ports (2-128). The function of the splitter is to split the optical signal from input to several outputs and in the reverse direction to merge it [8-10]. The splitter can be designed for a specific wavelength, or works with all wavelengths commonly used in optical transmission. Splitter is the largest insertion loss across the optical path. It is necessary to take into account the allowed optical signal attenuation due to a path attenuation, which is considered for EPON about 25 dB. The exclusive advantage of splitters is that merging and splitting of optical signals happens passively, thus eliminates the need for the implementation supply network and overall equipment reliability is very high. According to the production technology, splitters can be divided into Fused Bionic Taper (FBT) or Planar Lightwave Circuit (PLC).

Connecting splitters to the optical infrastructure ODN can be realized by connectors, welds or joints. It is often placed along with cartridges with stored reserves of optical fiber cables and pigtails in stands of optical distributors in van with standardized height in multiples U (Rack Unit = 45 mm). In Table-1 are shown the splitter attenuations, which value depends on the number of splitter output ports.

Table-1. Typical parameters of PLC.

Branching ratio	1:2	1:3	1:4	1:8	1:16	1:32	1:64	1:128
The split ratio	symmetric							
Maximum insertion loss [dB]	3.9	6.2	7.4	10.8	14.1	17.3	21	25.3
Typical insertion loss [dB]	3.5	5.8	6.9	9.8	13.5	16.5	20	23.5
Maximum uniformity [dB]	0.5	0.6	0.6	1.0	1.3	1.6	2	2.8
Polarization loss [dB]	≤0.15						≤0.2	
Directivity [dB]	≥55							
Reflection attenuation [dB]	≥55							
Guaranteed range of wavelengths [nm]	1260-1650							
Guaranteed operating temperature range [° C]	-40 to +85							

4. EVALUATION OF PON BY OTDR

Nowadays, in case of damage or interruption of optical fiber, we need to find out at what distance from the beginning the problem disorder is [9], [10]. The backscatter method, also called OTDR (Optical Time Domain Reflectometer), is based on the periodic transmission of the short optical pulse to the optical fiber [11]. Due to the Rayleigh scattering in micro-in homogeneities in the volume of optical fiber core, a part of the optical power is reflected back to the beginning of the optical fiber and due to Fresnel reflection, big in homogeneities caused by dirt such as connectors or other interruptions in the optical fiber, can be located (Figure-3).

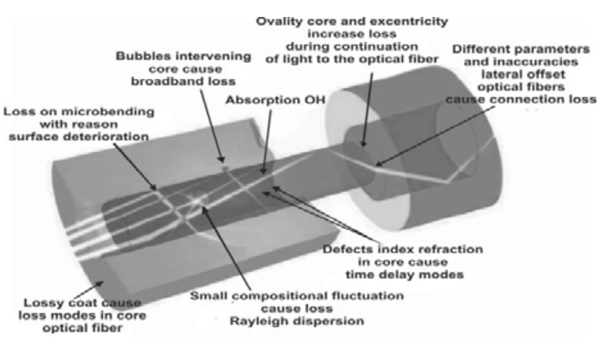

Figure-3. Scatterings that can be detected by OTDR.

A. Measurements using OTDR

For evaluation of the optical route between two buildings in the physical approach has been used the OTDR meter FTB-200 and ballast optical fiber with a length of 506 m, which is used to eliminate the dead band. The measurement was performed on wavelengths 1310 nm and 1550 nm with a pulse width of 100 ns. The measured length of the route was 1200 m; the average total measure time was over 60 seconds. According to Figure-4 we can determine what type of in homogeneity of fiber line is observed.

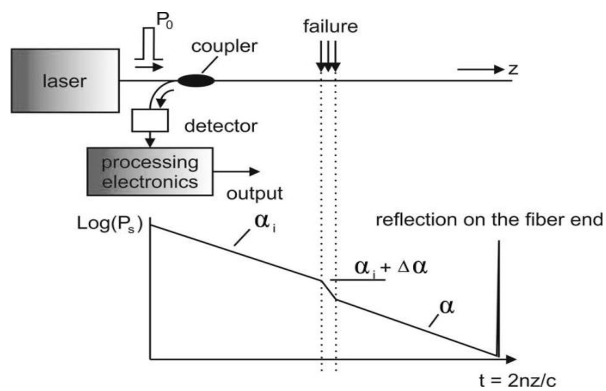

Figure-4. OTDR backscatter diagram.

B. Evaluation of Optical Networks

The resulting curves of PON (with/without splitter) at a wavelength 1310 nm are shown in Figure-5 and the resulting values are in Table-2. The measurement at a wavelength of 1310 nm is made for localization of optical welds and connector connections. First reflection occurs from an upstream end of the fiber thus the connector E2000 / APC. Second reflection is in case of PON optical network from the weld and from optical splitter. The third reflection occurs from the end of the optical path length 831 m ± 2 m.

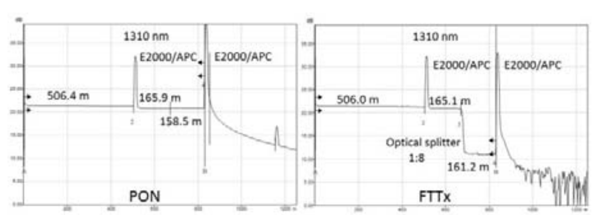

Figure-5. The resulting curves of PON at a wavelength 1310 nm.

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Table-2. The measured values of PON at a wavelength 1310 nm.

No	Loc. (km)	Event Type	Loss (dB)	Refl. (dB)	Att. (dB/km)	Cumul. (dB)
1310 nm						
1	0.0000	Launch Level	---	-65.5		0.000
		Fiber Section (0.5064 km)	0.181		0.357	0.181
2	0.5064	Reflective Fault	0.382	-38.0		0.562
		Fiber Section (0.1659 km)	0.086		0.519	0.648
3	0.6723	Positive Fault	-0.152			0.497
		Fiber Section (0.1585 km)	0.060		0.376	0.556
4	0.8308	Reflective Fault	---	>-23.1		0.556
1310 nm with PLC						
1	0.0000	Launch Level	---	-65.5		0.000
		Fiber Section (0.5060 km)	0.177		0.350	0.177
2	0.5060	Reflective Fault	0.287	-37.5		0.464
		Fiber Section (0.1651 km)	0.094		0.571	0.558
3	0.6711	Non-Reflective Fault	9.669			10.221
		Fiber Section (0.1612 km)	0.274		1.700	10.501
4	0.8323	Reflective Fault	---	-15.3		10.501

The resulting curves PON at a wavelength 1550 nm are shown in Figure-6, and the resulting values are in Table-3. The measurement at a wavelength 1550 nm is made for better diagnosis and localization of bends and thus potential faults detection is possible along the route.

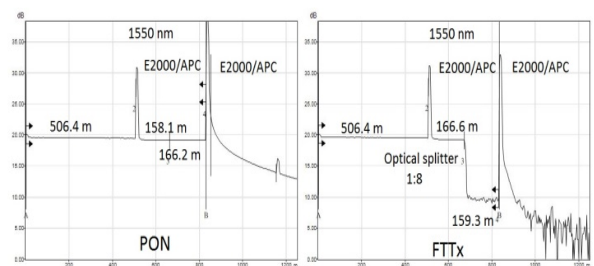

Figure-6. The resulting curves of PON at a wavelength 1550 nm.

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Table-3. The measured values of PON at a wavelength 1310 nm.

No	Loc. (km)	Event Type	Loss (dB)	Refl. (dB)	Att. (dB/km)	Cumul. (dB)
1550 nm						
1	0.0000	Launch Level	---	-67.6		0.000
		Fiber Section (0.5064 km)	0.108		0.214	0.108
2	0.5064	Reflective Fault	0.279	-39.2		0.387
		Fiber Section (0.1581 km)	0.107		0.674	0.494
3	0.6645	Positive Fault	-0.044			0.450
		Fiber Section (0.1662 km)	0.025		0.153	0.475
4	0.8307	Reflective Fault	---	>-22.1		0.475
1550 nm with PLC						
1	0.0000	Launch Level	---	-67.4		0.000
		Fiber Section (0.5064 km)	0.105		0.207	0.105
2	0.5064	Reflective Fault	0.182	-38.7		0.287
		Fiber Section (0.1666 km)	0.163		0.976	0.449
3	0.6730	Non-Reflective Fault	9.433			9.882
		Fiber Section (0.1593 km)	0.239		1.500	10.121
4	0.8322	Reflective Fault	---	-14.8		10.121

CONCLUSIONS

This article defines the basic types of PON. The aim was to create and evaluate the optical networks. OTDR measurement was implemented at the wavelengths 1310 nm and 1550 nm, which are commonly used in optical communication. The main advantage of PON without splitter was attenuation about 1 dB. However, the disadvantage of this network is the connection between the two buildings only. In second network we have used optical splitter with a ratio 1:8, which has the attenuation 10 dB more than is measured for PON, but with usage of a single fiber it can connect to more than one building. In terms of cost PON design appears preferable to PON with splitter but in terms of the number of possible user connections the PON with splitter is preferred.

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