FTTH UPGRADE TO WDM-PON

FTTH MIGRĀCIJA UZ WDM-PON

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The existing TDM-PON technologies like EPON or GPON have limitations of bandwidth due to the concept of time division. The bit rate can only be enlarged increasing the speed of the common channel. Another way of achieving the bandwidth growth is the use of WDM technology. The main problem of the TDM-PON expansion is the ability to use the existing cable plant for the upgrade to the WDM-PON. The paper will contain the simulation of the WDM-PON system with 16, 32, 64 users. The bandwidth per user will achieve 10 Gbit/s for download and 10 Gbit/s common channel for upload. The paper will demonstrate the investigation of limitations due to nonlinear effects and power margin decrease.

Introduction

Optical fiber access to the user, the so-called FTTH (Fiber-to-the-Home), is becoming a mature concept and a reality in many regions of the globe, with more than 4 million homes already connected only in Europe [1]. The number of connected users is growing exponentially. It is widely accepted, FTTH is the only future proof technology that will be able to support the upcoming interactive multimedia services [4, 5].

Traditional optical solutions based on point-to-point architectures are expensive for access configurations. To achieve the aim of cheap access networks the passive point-to-multipoint topology has been developed. PON (Passive Optical Network) has more advances because the number of active equipment is relatively low, that can increase cost-efficiency and decrease complicity in maintenance compared with traditional solutions [3]. Current PON systems are generally based on TDM-PON (Time Division Multiplexing) and have bandwidth limitations due to fundamentals of time division. The main way of increasing the bit rate is the use of WDM-PON (Wavelength Division Multiplexing) [2].

However, the future upgrade of TDM-PON to WDM-PON must be cost-effective and must use the existing cable plant in the first step of the access network reconfiguration.

There are at least two main ways how to increase the bitrate for each customer: CWDM and DWDM (Coarse and Dense Wavelength Division Multiplexing). CWDM is cheaper but has also the limitation of bitrate per channel due to internal modulation of the laser source which is leading to frequency chirp. CWDM also is possible to use only with new fibers G.652 C/D with low water peak, old types of G.652 can allow transmission of only 8 channels in the region where EDFA (Erbium Doped Fiber Amplifier)can't work. The main solution of future multi gigabit access networks is DWDM. In spite of the expensive price of today's DWDM components, the mass production and new technology of manufacturing can achieve the aim of cost-effective satisfaction of the bandwidth demand [1].

System Design and Simulation

Classical PON realisation is expanded with AWG (Arrayed Waveguide Grating) on OLT side and two filters on OLT and ONU sides to divide Downlink from Uplink. For the realisation of WDM-PON were chosen

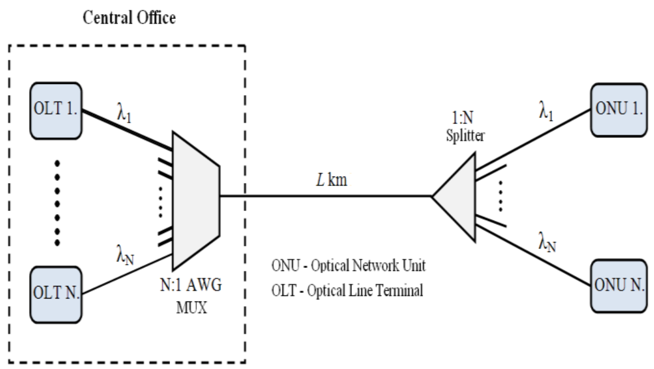

Fig. 1. WDM-PON structure

standard components to make the system less complicated and easy for install. All the component IL (Insertion Loss) and technical data are viewed in the Table.

Table 1

Technical specification

Length of the line	10 km
Laser output power	+3dBm
1:16 splitter IL	13,5 dB
1:32 splitter IL	17 dB
1:16 AWG IL	3,5 dB
1:32 AWG IL	5 dB
1:64 AWG IL	6,2 dB
Filter IL	1,2 dB
APD sensitivity	-24dBm
Fiber attenuation per 1 km	0,2 dB/km
Splicing loss	2,1dB

The aim of the investigation was to find out the limit of using standard PON configuration with power splitter for 16, 32 and 64-channel systems. The goal was the maximum available power margin to achieve the BER (Bit Error Rate) not worse than $1\cdot10^{-12}$. Using Optsim simulation software was proved, that it is possible to upgrade only 16-channel system. There is not enough power margin (1.45 dB) to run the 32-channel system with a splitter. AWG must be used on the receiver side like in the 64-channel system.

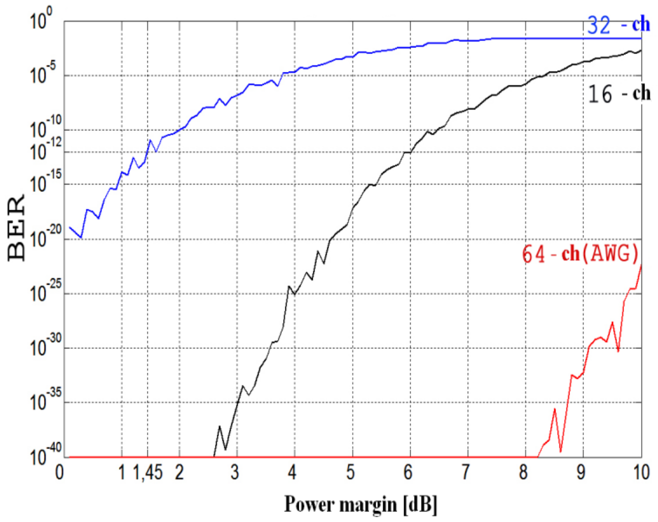

Fig. 2. BER dependence on extra power margin

To enlarge the power margin must be either reduced losses or increased the output power of laser (with external modulator). In spite of simplicity of this solution (it could be done using either EDFA or semiconductor optical amplifier), there is a fundamental limitation called SBS (Stimulated Brillouin Scattering).

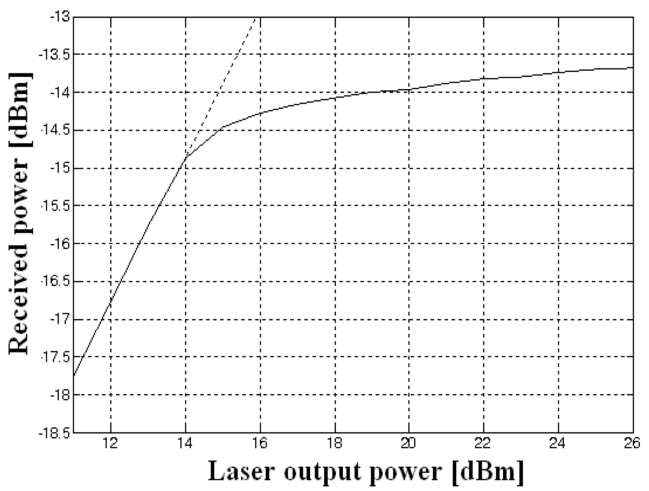

Fig. 3. Output power dependence on input due to SBS

It limits the maximum input power at a level of 8 dBm for the laser with FWHM (Full Width at Half Maximum) 10 MHz and 10 km of G. 652 fiber. Fig.3 shows us the effect of SBS. We see that the increase of power is linear till the moment, where SBS begin to affect the system. The received power doesn't increase after the level of 14 dBm (connector and AWG losses are 6 dB that is why the real power inserted in the fiber is approximately 8 dBm as it was calculated with Optsim before). It means that there is no reason to increase the output power after the level of 14 dBm.

Conclusion

Upgrade of EPON system (16 channels) is less complicated action and could be done adding AWG on the OLT side. GPON system (32 and 64 channels) is upgradable only using extra AWG on the receiver side or using more powerful laser sources.

If we use lasers with maximum available power due to SBS, it can grant the power margin of 9.35 dB for the 32-channel solution and 4.8 dB for the 64-channel system. It is clear that it is not obligatory to use maximum output power.

The vendor can choose what is cheaper: use extra AWG and rebuild the system or use more powerful lasers and don't make any outstanding changes with saving the money for the installation expenses.

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He has experience in fiber optics installation and maintenance also in mobile network support and multiservice operator. Current position is the researcher in fiber optics laboratory in Riga Technical University.

И.Ляшук, FTTH миграция к WDM-PON

Существующие TDM-PON технологии EPON и GPON имеют ограничения полосы из-за концепции временного разделения. Скорость может быть увеличена, только поднимая скорость общего канала. Другой путь достижения увеличения скорости – применение технологии WDM. Основная проблема расширения TDM-PON - необходимость использования существующей кабельной инфраструктуры для скорейшего перехода на WDM-PON. Статья содержит в себе симуляцию системы WDM-PON для 16, 32, 64 пользователей. Скорость для каждого абонента достигает 10 Гбит/с вниз и 10 Гбит/с в общем канале вверх. Статья демонстрирует исследование ограничений бюджета мощности из-за нелинейных эффектов.

I.Ļašuks, FTTH migrācija uz WDM-PON

Eksistējošajām TDM-PON tehnoloģijām EPON un GPON ir joslas ierobežojumi laika blīvēšanas koncepcijas dēļ. Ātrums var būt palielināts, paaugstinot kopēja kanāla joslu. Cita pieeja ātruma palielināšanai ir WDM pielietošana. Galvenā TDM-PON paplašināšanas problēma ir nepieciešamība izmantot jau eksistējošo instalēto kabeļu tīklu ātrākai pārejai uz WDM-PON arhitektūru. Pētījums ietver sevī WDM-PON sistēmas simulāciju uz 16, 32 un 64 abonentiem. Katram abonentam lejupielādes ātrums ir 10 Gbit/s un augšupielādes ātrums ir 10 Gbit/s uz kopējo kanālu. Raksts arī ietver sevī pētījumu par nelineāro efektu ietekmi uz jaudas budžeta samazināšanu.