Transponder for Coarse WDM Optical Communication Systems

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***Abstract*— A bi-directional optical transponder is described. The definition and objectives behind the construction of this device are shown. This device suits the requirements of Coarse WDM optical communication systems.**

***Index Terms*— Transponder, CWDM, FEC, BER.**

I. The Transponder

According with the etymology **Trans**mitter-Res**ponder** a transponder is a device that will generate a specific signal in response to a given input signal that may or may not be of the same physical nature.

A bi-directional transponder was implemented to meet the requirements of CWDM (Coarse Wavelength Division Multiplexing) systems. The device implements the interface between the client and the network. As shown in figure 1.

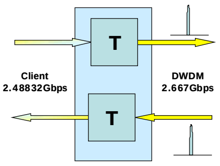

Fig. 1 – Representation of a bi-directional transponder

The utility of the transponder is to convert a signal intended to be transmitted in short-distance paths, typically between local equipments, and a signal intended to be transmitted in long-distance paths, typically between remote equipments [1].

Figure 2 shows an example of an optical network in ring configuration. Transponders will interface the clients to the optical network core. In this project the incoming and outgoing information from the client is provided by STM-16 SDH frames with bit-rate equal to 2.48832 Gbps. The core of the optical network has typical distance paths with tenths of kilometers and optical channel separation defined by the CWDM ITU-T grid [2].

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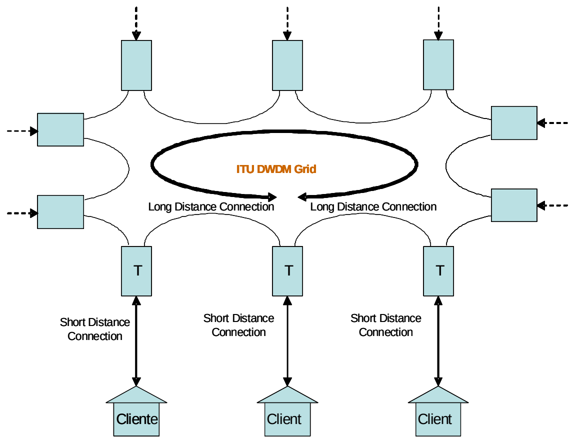

Fig. 2 - Example of an optical network ring configuration.

II. Migration to Coarse Wavelength Division Multiplex (CWDM)

During the developing of the project some questions were raised concerning the power consumption, the hardware complexity, physical dimensions and reliability. The migration of the transponder design project to the CWDM grid defined by ITU-T [3] had in consideration technical aspects described below. The first one is related with the optical spectrum that can be observed in figure 3.

A. *Optical Spectrum*

It can be seen from figure 3 that the optical spectrum of a CWDM system is much wider than a DWDM [2] system. Therefore CWDM channels have much less interference between them than DWDM channels.

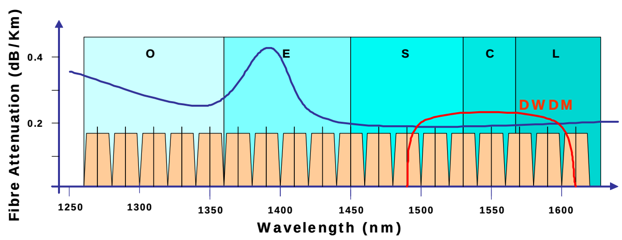

Fig .3 - Optical spectrum for DWDM and CWDM standards

The development of new fibres without the absorption peak due to the hydroxide ion, visible in the figure 3, make CWDM transmission distances equal to DWDM ones when considering only the attenuation limits.

B. Power Requirements

Power supply requirements for a DWDM laser are much higher compared to a CWDM laser. This difference of power consumption is manly because a DWDM requires a very tight temperature control. In the DWDM grid the 100GHz spacing between channels is equivalent to 0.8nm and it is required a temperature drift less than 0.08nm/ºC. The CWDM 20nm spacing between channels is large enough to allow the central wavelength of the laser to drift without causing any interference in neighboring channels, even under modulation. Having in mind that a DFB (distributed feedback) laser with a cooling circuit requires 5 W of power supply and that without cooling only demands 0.5 W a CWDM laser is more advantageous, since it is a non-cooled device.

C. Physical Dimensions

The physical dimensions of a CWDM laser are smaller compared to a DWDM laser as they do not include the cooler element (a Peltier device). It is important to refer that optical power monitoring allows the control of the laser bias point and counteract semiconductor aging.

III. FEC Introduction

As a consequence of long distance transmission the Bit-Error Ratio (BER) is quite high if the signals are injected in the core without any kind of redundancy. One technique is used here that helps to reduce significantly this parameter and is the insertion of Forward Error Correction (FEC).

Forward Error Correction is a technique that introduces redundancy in the information to be transmitted and is adopted in long-haul paths like submarine transmissions [4].

Figure 4 exemplifies the difference of performance of an optical path with and without FEC.

In figure 4 it is defined a gain code D that expresses the difference of power required in the receiver between a system

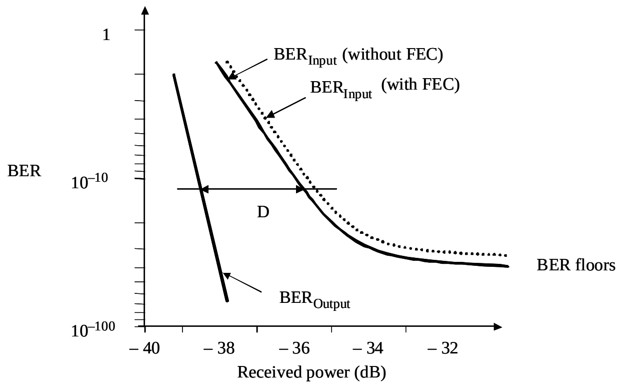

Fig. 4- Gain Code evaluation schemes. ITU-T G.975 [4].

with FEC and without FEC, for a given BER. In the picture $BER=10^{-10}$.

Table 1 shows a quantitative comparison of the performance of an optical system with and without FEC.

The introduction of FEC in optical networks is justified in the sense that optical links in a network can have quality of service (QoS) degradation related to several factors.

TABLE I
THEORETICAL OTPUT VERSUS INPUT BER.

BER_{input}	BER_{output}
10^{-4}	$5\ 10^{-15}$
10^{-5}	$6.3\ 10^{-24}$
10^{-6}	$6.4\ 10^{-33}$

IV. Transponder Architecture

Transponder block diagram is characterized in figure 5. The present technology available and the physical dimensions of the devices had influence in the final architecture decision.

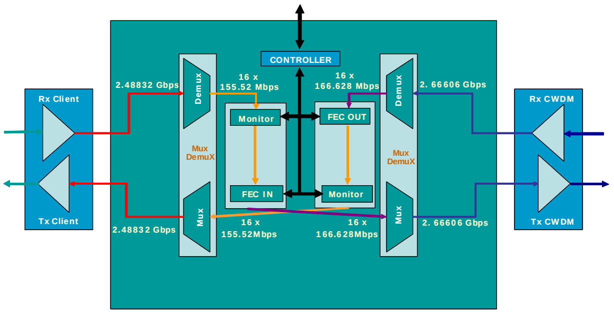

Fig. 5- Transponder block diagram.

V. Conclusions

The main goals of developing a transponder for metropolitan and large area optical networks were achieved. Different areas were joined, optical communications and electronics, making possible the construction of a device with innovating characteristics for optical networking. One of design requirements was also the implementation in only one PCB card making it attractive for commercial purposes.

References

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[5] MAXIM, APP 1085, "Choosing The MAX1932 External Inductor, Diode, Current Sense Resistor, and Output Filter Capacitors for Worst Case Conditions", 2002 http://www.maxim-ic.com/appnotes.cfm/appnote_number/1805/ln/en