IEEE 802.3 Ethernet Working Group
Liaison Communication

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Subject: Reply to ISO/IEC JTC 1/SC 25/WG 3 N 1398 on the impact of optical return loss (ORL) on passive optical network (PON) applications

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[1] This document solely represents the views of the IEEE 802.3 Working Group and does not necessarily represent a position of the IEEE, the IEEE Standards Association, or IEEE 802.

Dear Mr Oehler,

Thank you for your inquiry regarding the return loss of Passive optical networks (PONs). These have been specified to be tolerant of optical distribution network (ODN) reflections, including reflections from connectors. Indeed, many PONs extensively use PC-type connectors in their design and construction. The relevant specifications can be found in the IEEE and ITU-T documents.

In IEEE 802.3, the physical medium dependent (PMD) sublayers for 1GE-PON, 10GEPON, and 2x25GEPON are defined in Clauses 60, 75, and 141; respectively. The salient specifications are largely the same for all these systems.

Transmitter ORL tolerance (min)	-15	dB	
Transmitter reflectance (max)	-10 or -6	dB	
Receiver reflectance (max)	-12	dB	
~~Optical return loss of ODN (min)~~	~~20~~	~~dB~~	~~(1 and 10G)~~
Maximum discrete reflectance~~reflection~~	-26	dB	~~(25G)~~

The 1G-EPON, 10G-EPON, and 25G-EPON transmitters expect the ODN optical return loss of at least 20dB. All of these systems use Non-Return to Zero (NRZ) line coding with an intensity-modulated direct detection method. As such, they are relatively immune to the impact of reflections. At the lower speeds, an important effect was the instability of the laser transmitter due to reflections; however, this was positively eliminated by using an optically isolated or externally modulated transmitter at the higher speeds. As speeds have increased, the impact of optical multi-path interference becomes important. Hence, the limitations on Tx and Rx reflectance in combination with the ODN ORL must be observed.

The basic derivation of the ORL specifications can be found in ITU-T G.983.1 App. I. If the ODN is carefully constructed and all unused connectors are terminated, then the ORL should be higher than 32 dB. The assumption was that PC-type connectors would be used in PON systems, and the return loss of a PC-type connector is better than 35 dB, thus an allowance of 32 dB was appropriate. This is likely to be the case from the perspective of the optical network unit, as it is looking up through the very directive splitter at the well-matched path all the way to the optical line terminal (OLT). In contrast, from the OLT's perspective, it is quite likely that some of the splitter ports will be unterminated and so could exhibit a worst case ORL of 14 dB. Since there must be at least a 1:2 splitter, and this has a one-way insertion loss of 3 dB, a worst case ORL of 20 dB could be projected.

It should be noted that there are a few PON systems that use an "RF-overlay" third wavelength to deliver analogue Cable Television signals to the ONUs. This RF signal is fairly sensitive to reflections, and so these systems have typically used APC or UPC-type connectors to achieve a better ORL.

~~It is also important to take stock of the practical situation. At present, there are about 1 billion PON served users in the world, so the ODN has been built out to a large extent in many countries. All of this has been done in compliance with the above specifications. Anecdotal evidence suggests that most of the as-built networks comply. There have been some exceptions, but those cases were remediated and repaired. Thus, the ODN ORL range of 20 to 32 dB is a practical reality in most cases.~~

Hopefully, the above information and discussion will help you in your work. We are also interested in learning more about your current work in this area to better understand your requests. If you have any questions regarding PON specifications, please do not hesitate to contact us again.

Sincerely,
David Law
Chair, IEEE 802.3 Ethernet Working Group