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100G EPON Laser Safety Issues

Bill Powell, Fixed Networks CTO group

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Agenda

- Laser safety definitions and international testing/reporting requirements
- Past IEEE 802.3 contributions on Laser Safety
- Current IEC60825-2 SM fiber laser safety limits vs. laser class
- Class 1, 1M, 3/3R implications
- Conclusions

Important definitions

(from IEC 60825-1[1]

- Class 1 laser product - any laser product which during operation does not permit human access to laser radiation (accessible emission, see 3.2) in excess of the AEL of Class 1 for applicable wavelengths and emission durations (see 5.3 and 4.3 e)
- Class 1M laser product - any laser product in the wavelength range from 302,5 nm to 4 000 nm which during operation does not permit human access to laser radiation (accessible emission, see 3.2) in excess of the AEL of Class 1 for applicable wavelengths and emission durations (see 4.3 e)), where the level of radiation is measured according to 5.3 a)
- Class 3R & 3B laser product - any laser product which during operation permits human access to laser radiation (accessible emission, see 3.2) in excess of the AEL of Class 1 and Class 2, as applicable, but which does not permit human access to laser radiation in excess of the AEL of Classes 3R and 3B (respectively) for any emission duration and wavelength (see 5.3 d) and 5.3 e))
- Eye safe - accessible emission below the AEL of Class 1 or an exposure below the MPE (maximum permissible exposure) for the eye for the given exposure duration
- AEL – Accessible emission limit - maximum accessible emission permitted within a particular class, (and with a particular aperture)

Example regional laser testing and reporting requirements

(from Met Laboratories: http://www.metlabs.com/services/product-safety-testing/laser-safety/ [2])

- USA

  Federal law states that a product that employs a laser diode is a laser product. Typical laser products include CD players, laser pointers, fiber optic telecommunications equipment and the like. Federal law requires that laser products comply with the laser safety requirements of the Center for Devices and Radiological Health (CDRH), a division of the Food and Drug Administration (FDA). Laser safety requirements are contained in **21CFR Parts 1010 and 1040**. The requirements vary depending on the class of laser and the class is determined by power and wavelength characteristics of the laser source. Manufacturers of laser products are required to submit a report to the CDRH attesting to compliance with all applicable sections of 21CFR prior to placing laser products on the market. In addition to this report filing, manufacturers are also required to maintain certain records and may be required to submit periodic reports to the CDRH. Currently U.S. requirements only apply to laser diode sources and not to LEDs. For further information, refer to http://www.fda.gov/Radiation-EmittingProducts/.

- Canada

  Canadian law requires that laser products comply with the Canadian Radiation Emitting Devices Act, **REDR C1370**. Compliance with U.S. FDA requirements is sufficient evidence of compliance with Canadian law. The primary difference being that Canada requires notification of non-compliance of marketed equipment where the US requires notification that equipment is compliant before it is placed onto the market. For further information, refer tohttp://laws.justice.gc.ca/en/R-1/C.R.C.-c.1370/index.html.

- European Union

  Compliance with European Directives such as the Low Voltage, Medical Devices, Machinery or even the General Product Safety Directives require that laser products comply with **EN 60825-1** (laser products) and, if applicable, **EN 60825-2** (fiber optic laser products) in addition to other requirements of the Directives. Compliance is assured through a successful investigation to the applicable laser standard as well as the applicable end-product standard (e.g. **EN 60950**) and is demonstrated by the manufacturer's self-declaration and application of the CE mark. European requirements apply to both laser diode-based products and LED products, which is a major difference from US requirements.

Past IEEE 802.3 contributions on Laser Safety

- A past 802.3av (10G EPON) contribution[3] contains much useful info on optical fiber safety issues, but focused on single-wavelength SM fiber O-band optical fiber laser classification levels, which differ from C/S/L band optical fiber classification level limits

- A past 802.3ba (40 & 100 Gb/s Ethernet) contribution[4] also contains much useful info on optical fiber safety issues, but focused on multi-lane, multi-fiber (12 fiber ribbon cable), multimode (850 nm) optical fiber laser classification levels, which differ from single fiber, SM fiber, O/C/S/L band optical fiber classification level limits

Single Mode Fiber power vs. Laser Class

(from IEC 60825-2[5]

Table D.1 – OFCS power limits for 11 µm single mode (SM) fibres and 0,18 numerical aperture multimode (MM) fibres (core diameter < 150 µm)

Wavelength and fibre type	Hazard Level					
	1	1M	2	2M	3R	3B
633 nm (MM)	1,95 mW (+3 dBm)	3,9 mW (+5,9 dBm)	4,99 mW (+7 dBm)	10 mW (+10 dBm)	24,9 mW (+14 dBm)	500 mW
780 nm (MM)	2,81 mW (+4,5 dBm)	5,6 mW (+7,5 dBm)	–	–	14,4 mW (+11,6 dBm)	500 mW
850 nm (MM)	3,88 mW (+5,9 dBm)	7,8 mW (+8,9 dBm)	–	–	19,9 mW (+13 dBm)	500 mW
980 nm (MM)	7,06 mW (+8,5 dBm)	14,1 mW (+11,5 dBm)	–	–	36,2 mW (+15,6 dBm)	500 mW
980 nm (SM)	1,8 mW (+2,6 dBm)	2,66 mW (+4,2 dBm)	–	–	9,21 mW (+9,6 dBm)	500 mW
1310 nm (MM)	77,8 mW (+18,9 dBm)	156 mW (+21,9 dBm)	–	–	399 mW (+26 dBm)	500 mW
1310 nm (SM)	25,8 mW (+14,1 dBm)	42,8 mW (+16,3 dBm)	–	–	129 mW (+21,1 dBm)	500 mW
1 400 nm 1 600 nm (MM)	13,3 mW (+11,2 dBm)	384 mW (+25,8 dBm)	–	–	See note to 3.9	500 mW
1 420 nm (SM)	10,1 mW (+10 dBm)	115 mW (+20,6 dBm)	–	-	See note to 3.9	500 mW
1 550 nm (SM)	10,2 mW (+10,1 dBm)	136 mW (+21,3 dBm)	–	–	See note to 3.9	500 mW

SM - O-Band

SM - E-Band

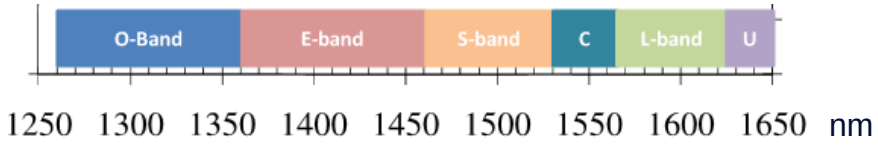
SM – S/C-Bands

Source: IEC60825-2 (IEC:2004+A1:2006+A2:2010)

- Aggregate power for 4 lanes is 6 dB higher than power for 1 lane (w/equal power/lane)
- O-Band SM fiber power limits:
  - Class 1: +14.1 dBm (**max. +8.1 dBm/lane**);
  - Class 1M: +16.3 dBm (+10.3 dBm/lane)
- E-band not likely to be used (water peak attenuation)
- S/C-Band SM fiber power limits:
  - Class 1: +10.1 dBm (**max. +4.1 dBm/lane!**)
  - Class 1M: +21.3 dBm (+15.3 dBm/lane)

SM fiber optical bands

Source: 802.3 IC - NG EPON TR (Fig. 51)



OFCS – Optical Fiber Communications Systems

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Conclusions

- All public network OFCS laser products will need to be safety tested/certified by competent optical safety test labs, appropriately classified, and appropriately safety labeled
- Certain regions require additional testing & reporting
  - U.S. – IEC 60825-1/2 laser classification, testing, labeling, & FDA/CDRH laser product reporting
  - Canada – Industry Canada laser testing and labeling; non-compliance reporting
  - European Union – EN60950 safety testing, IEC60825-1/2 testing/classification, labeling, CE Marking
- Laser products with classification levels from Class 1 through 3R are possible product classifications => Higher classification levels require additional testing, safety measures, and increased labeling
- Recommended we stay below Class 3/3R optical fiber power levels

References

1. IEC 60825-1 (Edition 3.0, 2014-05) Safety of laser products – Part 1: Equipment classification and requirements
2. Metlabs, Laser Safety: Information for Products Employing Laser Devices and LEDs
3. Kolesar, “Laser Safety Standards,” 3av_0611_kolesar_1.pdf, IEEE 802.3av contribution, Commscope, November, 2006
4. Petrilla, “Multilane MM Optics: Eye Safety Categories,” petrill_02_0308.pdf, IEEE 802.3ba contribution, Avago Technologies, March, 2008
5. IEC 60825-2 (Edition 3.2, 2010-12) Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)
6. 21 CFR 1040.10 (Title 21, Vol. r81, Revised April 1 2007) Performance Standards for Light-Emitting Products
7. Laser Products – Conformance with IEC 60825-1 and IEC 60601-2-22; Guidance for Industry and FDA Staff (Laser Notice No. 50, June 24, 2007)

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