Herwig Stange

Protecting the eyes against infrared radiation:

Safe laser transceivers for high-speed data communications

Infrared light emitted from semiconductor lasers is invisible, but still hazardous to the human eye. This drawback is common to the laser transceivers increasingly used in data communications. How can the benefits of such transceivers – high data rates, transmission over long distances and low susceptibility to electromagnetic interference – be exploited without any risk to health?

Basically, the answer is quite simple: the power of the laser radiation escaping must not exceed a critical value determined by the mechanisms that cause eye damage. These mechanisms are highly sensitive to the wavelength of the laser light. Many optical data communication systems use the second optical window of quartz fibers in the spectral range of 1.3 µm. The human eye cannot see this infrared light or, to be more specific, the eye's receptors – the retinal rods and cones – are insensitive to this region of the electromagnetic spectrum. Nevertheless, infrared light penetrates the cornea and vitreous body just like visible light and is focused by the lens of the eye.

To assess the potential risks, the energy density of the spot of light focused onto the retina must be examined. The mechanisms causing eye damage are well understood, as has been documented by extensive therapeutic laser applications in medicine. This knowledge is the basis of standards that define the maximum levels of laser radiation permitted.

Standards define maximum levels

Two important standards must be observed before a laser product or component can be marketed worldwide:

❄ global standard IEC 825-1 of the International Electrotechnical Commission; and

❄ regulation 21 CFR Chapter 1, Subchapter J, of the Center for Devices and Radiological Health (CDRH) of the Food and Drug Administration (FDA) for the US market.

Both standards divide all laser products into four classes. This classification gives users an idea of the potential hazards posed by the laser and lays down the necessary precautions they have to take. Such precautions may include special training for personnel or wearing safety goggles.

Laser Class 1 is the highest safety class defined by these standards. Class 1 laser products therefore impose the fewest constraints on manufacturers and users. The widespread use of CD players and laser printers, for example, shows that lasers present no hazards to users as long as the products satisfy Laser Class 1 safety requirements.

But laser safety is an important feature of optical data links too. The easiest way to meet Laser Class 1 requirements in optical fiber data links is to use safe components from the outset, because the safety of the laser transceivers guarantees the laser safety of the entire system. It is nevertheless difficult to develop laser transceivers that satisfy the different requirements set by both standards for Laser Class 1.

In principle, the safety of the lasers in the transceivers can be achieved in three different ways: mechanically, optically and electronically.

Mechanical solutions

These include the use of shutters to prevent laser radiation escaping from the transceiver, even when there is no connector inserted in the optical port of the transceiver. However, as transceivers should always have small mechanical dimensions, shutters would increase the size of the optical port, which would conflict with standards set to ensure transceiver compatibility.

Optical solutions

Optical approaches aim to achieve high coupling efficiencies and divergent emissions in order to reduce the intensity of the radiation reaching the eye from the open port. This can be implemented in the port by using a fiber stump and a slit sleeve to permit physical contact between the stump and connector. But even slight contamination, which is always possible in common transceiver applications, can cause severe losses or reflections that interfere with the laser. Both effects can even disrupt the optical fiber link altogether.

The electronic alternative

The third option is a solution based on electronic safety shutdown, which can be integrated into the transceiver at little extra expense. This is much more cost-effective than any other solution – mechanical or optical.

Laser transceivers of type SM-ATM OC-3 1×9 (**Fig. 1**) and the Giga Link Card (GLC) (**Fig. 2)** feature electronic safety shutdown and comply with all requirements of Laser Class 1. This compliance has been certified by authorized safety bodies (e.g. TÜV Berlin-Brandenburg, VDE).

The SM ATM-1×9 transceiver for 155 Mbit/s satisfies ATM Forum and ITU-T SDH specifications and can be used in a wide field, from private datacom to public telecom systems. Typical applications cover short distances, e.g. SONET with transmission routes up to 15 km. The optical interface is a duplex SC port.

The laser power of the SM ATM transceiver is supervised by a monitor diode, which is required in any case to regulate laser power so that the laser's temperature and degradation effects can be compensated. In the event of a fault, the laser is switched off to stop emission of hazardous infrared radiation. The fail-safe design of the SM ATM transceiver includes redundant features to ensure full eye protection against any fault and its consequences.

The Giga Link Card is a datacom transceiver of very high performance and reliability. It is used to connect two or more computers in the domain of parallel data processing. This transceiver for 1 Gbit/s has a parallel TTL-compatible 20-bit bus and a serial optical interface with a duplex SC port. Its specification is based on the Fiber Channel Standard (FC) developed by the ANSI X3T11 study group.

As the Giga Link Card is used exclusively for optical point-to-point data links, a different type of electronic safety shutdown can be used. The Open Fiber Control System (OFC) detects any interruptions in the link and forces the transceiver to interrupt data transfer and transmit only short pulses at a very low repetition rate. The OFC system does not allow normal data transfer to resume until a special switching and routing procedure has checked that the optical fiber link is uninterrupted. The specification of the OFC system is an integral part of the Fiber Channel Standard. The system can be operated at higher optical powers which would normally exceed the limits of Laser Class 1. The advantage is a correspondingly higher power budget for optical transmission.

The two Siemens laser transceivers satisfy Laser Class 1 conditions of both the IEC 825-1 and CDRH standards, so they can be used worldwide. But laser safety requirements do not place any constraints on the design of datacom and telecom systems based on these transceivers because these Siemens components are intrinsically safe from the outset. This means that manufacturers do not have to classify their products, submit laser safety reports or to carry out extra tests during production – and the laser transceivers can be used easily and safely. ❋

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Fig. 1 View of an ATM transceiver with built-in eye protection to Laser Class 1

Designed for data rates up to 155 Mbit/s and SC duplex connectors, the transceiver is equipped with electronic protection circuitry to prevent hazardous laser radiation from escaping

Fig. 2 The Giga Link Card – shown here with the cover removed – can be used to transmit data between computers at rates up to 1 Gbit/s. This high-speed, high-performance laser transceiver also offers eye protection to Laser Class 1 and can be mounted as a complete module on larger circuit boards (e.g. an I/O interface board)