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2.5Gb/s Simple Optical Wireless Communication System for Particle Detectors in High Energy Physics

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We successfully demonstrated simple and low cost 2.5 Gb/s optical wireless transmission at 10 cm distance, aiming to be employed in high-energy physics experiments using off-the-shelf VCSEL and PIN photodiode with proper ball lens. The measured tolerance to misalignment is around ±1mm at Bit Error Rate of 10ˆ-12.

Summary

Particle physics experiments generate large amounts of data, whose transmission requires huge infrastructure of optical fibers. This increases the material budget, limits space and also introduces excessive labor cost for cables installation and management. High-speed Optical Wireless Communication (OWC) can be a viable solution to reduce the complexity of optical fiber networks for future upgrades. We are designing an OWC system for particle detectors, having as a reference application the inner tracker of Compact Muon Solenoid (CMS) operating in Large Hadron Collider (LHC) at CERN. The proposed OWC solution is not intended to completely substitute the optical fiber links, but it will be rather used to introduce the radial connectivity between silicon strip sensors.

We have designed a 2.5 Gb/s OWC link, which comprises a VCSEL (1550nm) transmitter and a PIN photodiode with ball lens at 10 cm of transmission distance. In future, this simple and low cost design may be integrated on silicon strip sensors inside CMS or other short distance links in particle detectors.

After careful design of the receiver, we achieved a tolerance to misalignment in the range of ±1mm, which is important because, only passive alignment in range of ≥±0.25 mm is acceptable in particle detector systems. In this paper, we report the design of the OWC link and detailed tolerance to misalignment study, based on different diameter lenses at the receiver. By this analysis, we designed the custom packaging for the photodiode and a 4mm ball lens. The results of this activity will also be presented in the paper.

We are aiming to deploy the OWC link in high energy physics environment therefore, we have selected VCSEL and InGaAs PIN photodiode because of their radiation tolerance [J. Troska et al, IEEE Trans on Nuclear Sci, 58, 6, Dec 2011]. Moreover, we selected fused silica and quartz glass type lenses, since they only can provide proper irradiation properties, i.e. much better than BK7 glass at 1550nm [S.M. Javed Akhtar., et al, Optical Materials, Vol 29, 12, Aug 2007].Since these glass types are still tested for lower dose in future we will plan irradiation test in order to qualify the optical components and especially the lens in environments with high radiation level.

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