Error-free 10.7 Gb/s digital transmission over 2 km optical link using an ultra-low-voltage electro-optic modulator

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Abstract

We demonstrate the feasibility of 10.7 Gb/s error-free (BER < 10^{-12}) optical transmission on distances up to 2 km using a recently developed ultra-low-voltage commercial electro-optic modulator (EOM) that is driven by 0.6 Vpp and with an optical input power of 1 mW. Thus, the modulator could be driven directly from the detectors' board signals without the need of any further amplification reducing significantly the power dissipation and the material budget.

Introduction

The Large Hadron Collider (located at CERN, Geneva, CH) is foreseen to be upgraded in the future to reach an ultimate peak luminosity of 10^{35} cm^{-2} s^{-1}: that will be the so-called Super-LHC stage.

In the SLHC scenario, the bandwidth needed for data extraction from the detectors will grow significantly due to the huge particle content at high repetition rates.

Increase in bandwidth of the optical link is a key factor to allow fast data processing and to reduce latency times

Actual trend is focusing on increasing the data rate (5 Gb/s, in perspective 10 Gb/s).

The increase in the transmission bit rate could also significantly reduce the number of optical links per detector leading to volume and cost reduction.

Low voltage driving and low power consumption are requested features of the data link in order to keep low the required power budget.

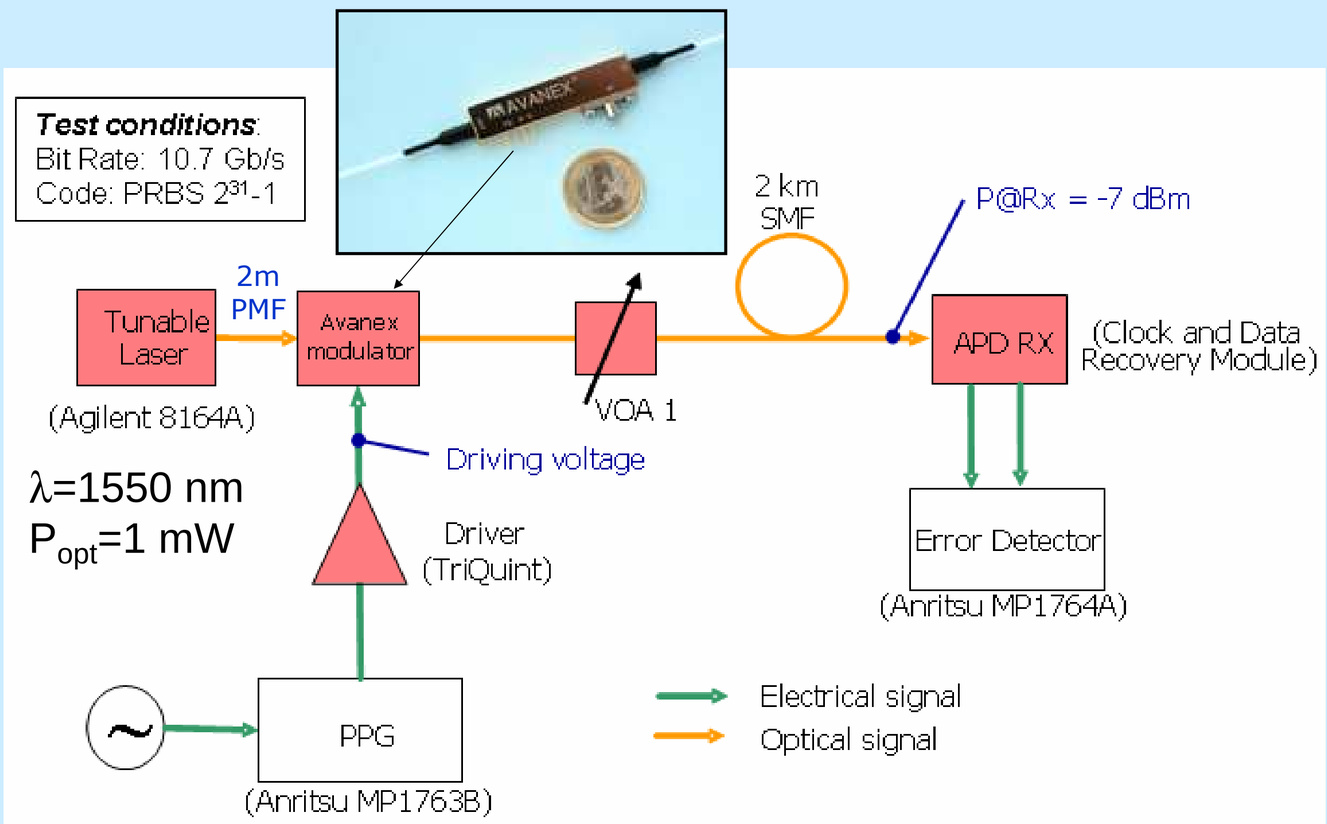
Lithium niobate EOMs allow to keep the laser source outside the hard radiation environment, with positive impact on the reliability of the system and on the detector global required power budget.

Developments and Applications

- Off-the-shelf Lithium Niobate (LN) Mach-Zehnder modulators are already able to reach 10 Gb/s and higher data rates.
- LN EOM are already proven to be radiation hard, resistant to high magnetic fields and able to operate at low temperatures (T~-20ºC).
- The physical dimensions of the 10Gb/s modulator used in our measurements are (48x9.3x5.0) mm^3 plus fibre connections (13 mm IN and 18 mm OUT). Options to further reduce overall footprint of the modulator are still open and under study.
- The estimated data rate from a tracking detector at SLHC is of the order of few Tb/s/detection layer (cylindrical shells): this implies the use of few hundred transmitters per layer at a digital rate of ≈10 Gb/s or larger. Use of EOM can avoid data transmission bottlenecks.
- Tests with 1300 nm single mode fibre, together with a study of polarization effects over the fibre lengths relevant for SLHC detectors, are already planned.

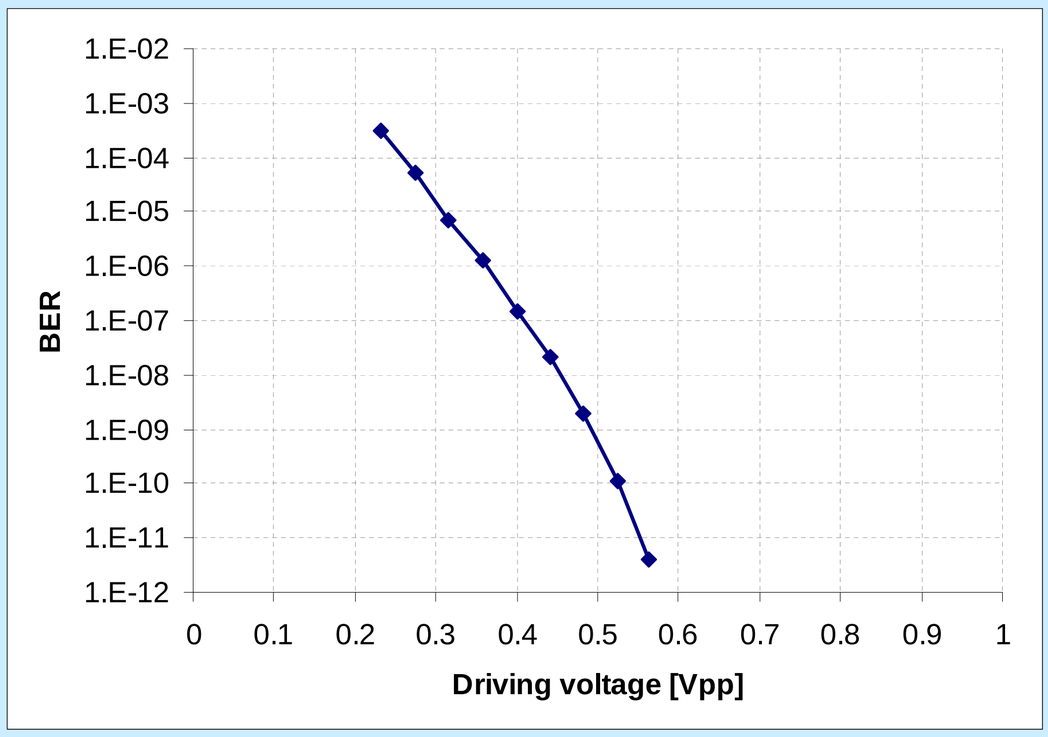
Link idea and measurement setup

Commercial LN ultra-low-voltage EOM tested in a 2 km fiber link



Bit-Error-Ratio vs. Driving voltage

Error-free transmission with V=0.6Vpp
Optical power = 1mW (@1550nm)



Conclusions and perspectives

- A demonstration of 10 Gb/s error-free (BER<1E-12) transmission on a 2km fiber optics employing a driving voltage as low as V = 0.6 Vpp (on 50 Ohm impedance) is given.
- This opens up the possibility of driving the modulators directly with buffered detection board signals.
- Further studies on form factor reduction are ongoing.
- Integration on boards and serialization of data are necessary to cope with SLHC requests.

References

- Reports at http://rd23.web.cern.ch/RD23/
- D. Janner, D. Tulli, M. García-Granda, M. Belmonte, V. Pruneri, Laser & Photon. Rev. 3, 301-313 (2009)
- F. Lucchi, D. Janner, M. Belmonte, S. Balsamo, M. Villa, S. Giurgiola, P. Vergani, V. Pruneri, Opt. Express 15, 10739-10743 (2007)