Optical transceivers for event triggers in the ATLAS phase-I upgrade

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Introduction: the dual-channel optical transceivers MTx, MTRx are fabricated for the phase-I upgrade of the ATLAS trigger electronics in the Liquid Argon Calorimeter (LAr) and the Muon New Small Wheel (NSW) Spectrometer [1,2]. The opto-electronics employed are the 850 nm multimode VCSEL (vertical cavity surface emitting laser) and a LOCld laser driven made of 0.25 μm Silicon-on-Sapphire (SoS) CMOS process [3].

MTx, MTRx modules are assembled with a LC latch to a reduced 6mm height for LAr [4], and in the commercial SFP+ format for NSW. The Rx modules are ROSA's with the photo detector current amplified by a CERN developed TIA. The components are investigated for ageing and fabricated for the phase-I upgrade of the ATLAS trigger electronics in the LAr [4], and in the commercial SFP+ format for NSW. The Rx VCSEL bias, output peaking and modulation.

Quality Assurance requires LOCld chips checked for currents and VC communication. TOSA's are measured for I-L-V curves. The assembled PCBs are tested before/after TOSAs being soldered. Complete modules are examined for currents, Tx outputs free of 10 Gbps Bit-Error <10⁻¹², light-powers and eye-diagrams. Channels failed Bit Error is less than 1%.

The eye-diagrams of 10 Gbps tests show a margin of 18%.

The Jig and DAQ setup measuring TOSA I-L-V is shown. Light power at 6 mA, between 550 μW to 800 μW is required for module production.

The LOCld chips are tested for currents and VC function (left). The assembled modules are tested for Bit-Error (middle), light power and eye-diagram (right).

Quality Control on modules is conducted for 5 Gbps data transmission in ATLAS applications. Eye-diagrams of Tx’s and Rx’s are examined. Bench setup and typical eye-diagrams are shown.

QC bench setup for 5 Gbps transmission

Bench setup for QC and example eye-diagrams of MTx, MTRx are plotted for data transmission of 5 Gbps at the LAr.

MTx/SFP+ type MTx

Test setup on carrier board is shown for the SFP+ type MTx. The carrier provides USB interface to PC for VC control, and inputs of electrical signals.

8 Gbps eye-diagram of a typical Tx channel.

Eye-diagram of a MTx-SFP+ channel at 10 Gbps. The average power is 870 μW with the amplitude of 1.1 mW. The margin to mask is 18 %.

QC criteria on parameters of 5 Gbps eye-diagrams are listed. The yield for the total 3300 MTx and 800 MTRx modules produced for LAr is 99%.

Uniformity of transmitter channels is attended. The TOSA's for the two Tx's on a MTx driven by one LOCld are paired for equal light power within 3%. Performance is compared and illustrated for the 8 Gbps eye-diagrams conducted on the first batch of 440 MTx’s. The ratios of both AOP and OMA between the two Tx’s show RMS values of 4 %. The margins of 8 Gbps mask are uniformly distributed in 39 ± 5 %.

Measurement of optical power shows a large uncertainty dominated by the light coupling of fiber ferrules to TOSA’s and to receivers. The Tx outputs are also measured with DC power meters. The deviation indicates a systematic uncertainty of 6 % on fiber light power measurements.

Ageing of MTx is monitored with burn-in of 24 modules in room condition. Bit-error rate at 10 Gbps and eye-diagrams are measured periodically. The burn-in has accumulated more than 6000 hours with no error observed. The power meter readings and eye-diagrams of AOP and OMA are compatible to initial values within the 6% systematic uncertainty dominated by the fiber coupling condition.

Quality Assurance

QC bench setup for 5 Gbps transmission

Bench setup for QC and example eye-diagrams of MTx, MTRx are plotted for data transmission of 5 Gbps at the LAr.

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