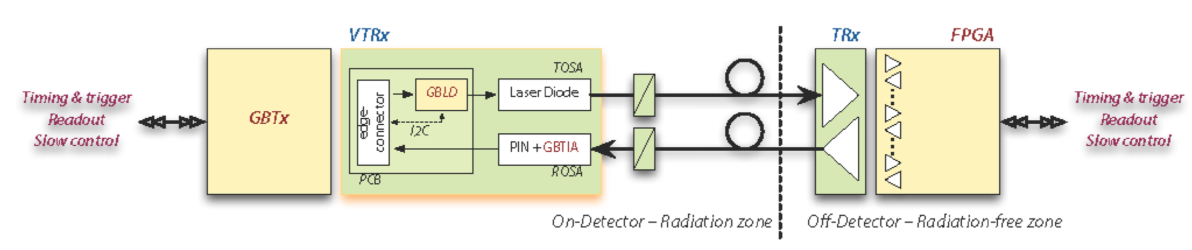
Temperature Characterization of Versatile Transceivers

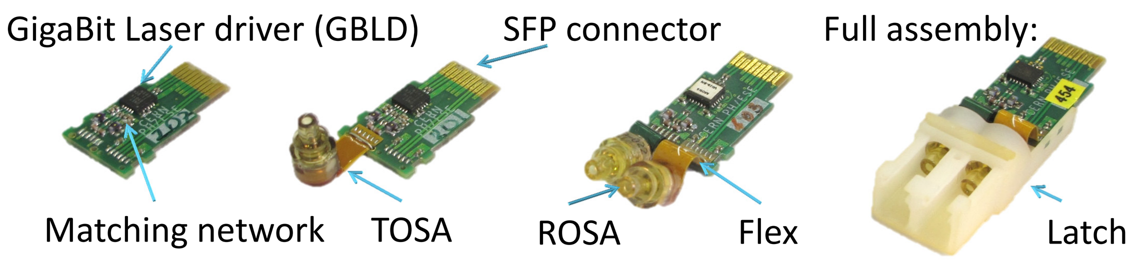
**Lauri Olanterä, Stephane Detraz, Sarah Seif El Nasr-Storey,
Christophe Sigaud, Csaba Soos, Jan Troska and François Vasey**

The Versatile Transceiver (VTRx) is a part of the Versatile Link project, which is developing optical link architectures and components for future HL-LHC experiments. While having considerable size and weight constraints Versatile Transceivers must work under severe environmental conditions. One such environmental parameter is the temperature: the operating temperature range is specified to be from -30 to +60°C. In this contribution we present the results of the temperature characterization of the VTRx Transmitter (TOSA) and Receiver (ROSA). Several TOSA candidates from three different manufacturers have been characterized: multi-mode Vertical Cavity Surface-Emitting Lasers and a single-mode Edge-Emitter Laser. Also both single- and multi-mode receivers have been tested.



Versatile Transceiver

The Versatile Transceiver (VTRx) is a radiation-resistant, low-power, and low-mass optical transceiver modules operating at rates up to 5 Gbit/s. The versatility is assured with multi-mode and single-mode versions operating at 850 nm and 1310 nm wavelength, respectively. The VTRx must operate in strong magnetic field and at temperatures ranging from -30 to +60°C. An important component of VTRx is in-house designed radiation hard GigaBit Laser Driver (GBLD). The GBLD is able to drive both VCSELs and edge-emitter lasers. The main focus is on modules using the GBLD, but for comparison similar TOSAs were tested using commercial laser drivers (ONET).



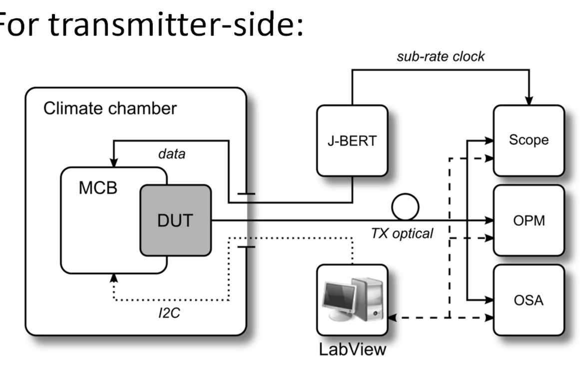
Parameters to be evaluated:

Dynamic parameters	Min	Max
Optical modulation amplitude	300 µW	
Eye height	0.6xOMA	
Extinction ratio	3 dB	
Rise/fall time		70 ps
Deterministic jitter		0.12 UI
Total jitter		0.25 UI
Receiver sensitivity, multi-mode single-mode		-13.1 dBm -15.4 dBm

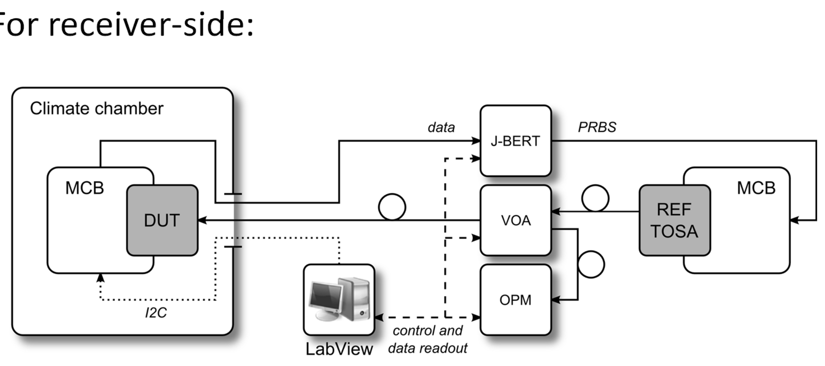
Static parameters	Min	Max
Threshold current, VCSEL edge-emitter		2 mA 10 mA
Slope efficiency, VCSEL edge-emitter	0.06 W/A 0.02 W/A	0.20 W/A 0.10 W/A
Central wavelength, multi-mode single-mode	840 nm 1260 nm	860 nm 1355 nm
Spectral width, multi-mode single-mode		0.65 nm 4 nm

Test Setup

For transmitter-side:

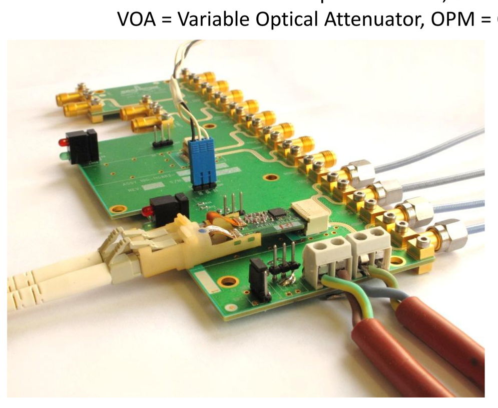


For receiver-side:

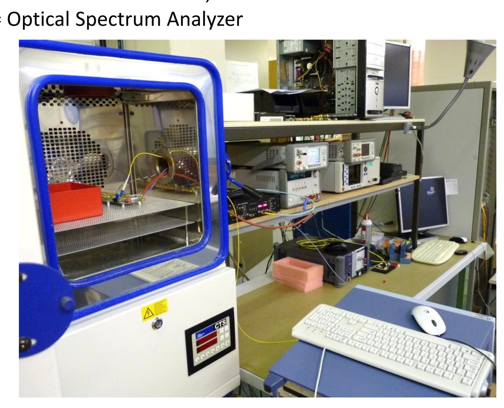


MCB = Module Compliance Board, DUT = Device Under Test, J-BERT = Bit Error Ratio Tester,
VOA = Variable Optical Attenuator, OPM = Optical Power Meter, OSA = Optical Spectrum Analyzer

VTRx on module compliance board (MCB)

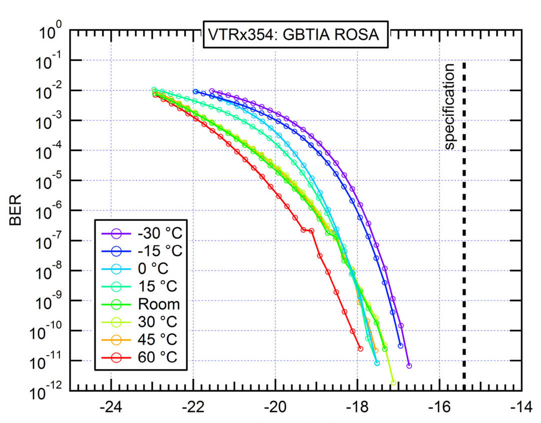


DUT inside climate chamber

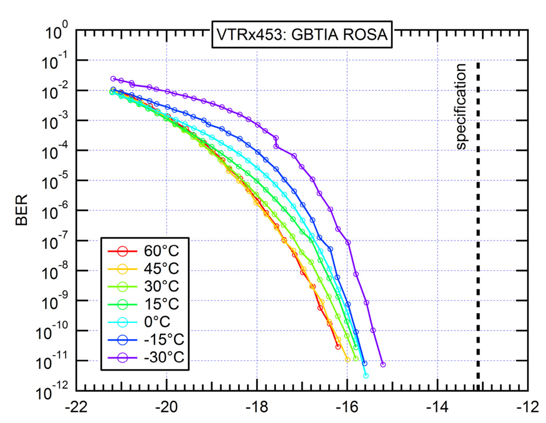


Receiver sensitivity

BER curve was measured with a receiver inside the climate chamber.
Receiver sensitivity met the specifications over whole temperature range,
even though there is some degradation when temperature is decreased.



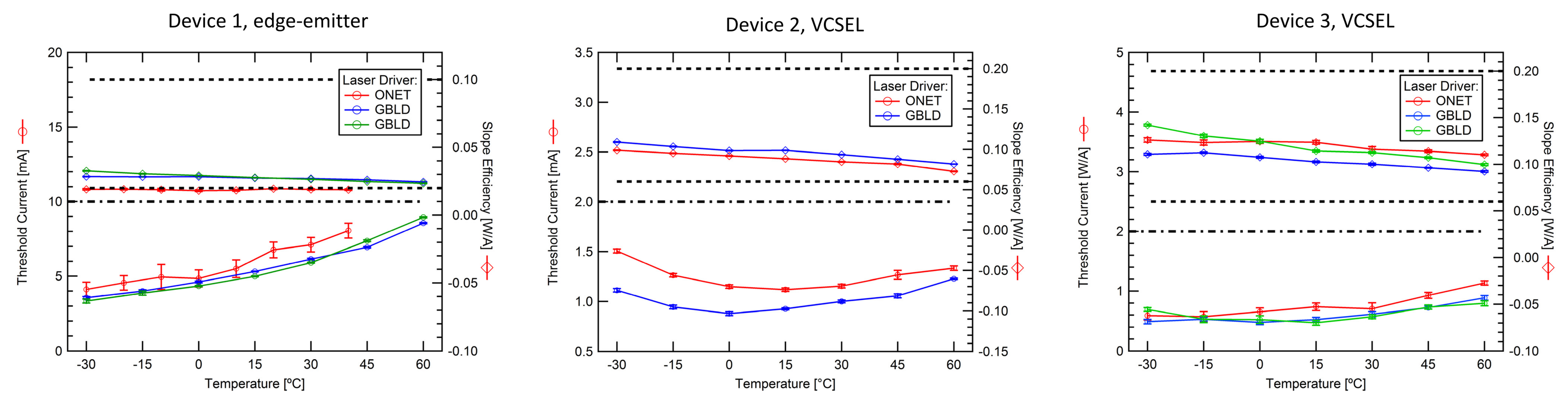
ROSA with InGaAs photodiode 1310 nm
(allows operation at both 850 and 1310 nm wavelengths)



ROSA with GaAs photodiode 850 nm

Transmitter characteristics

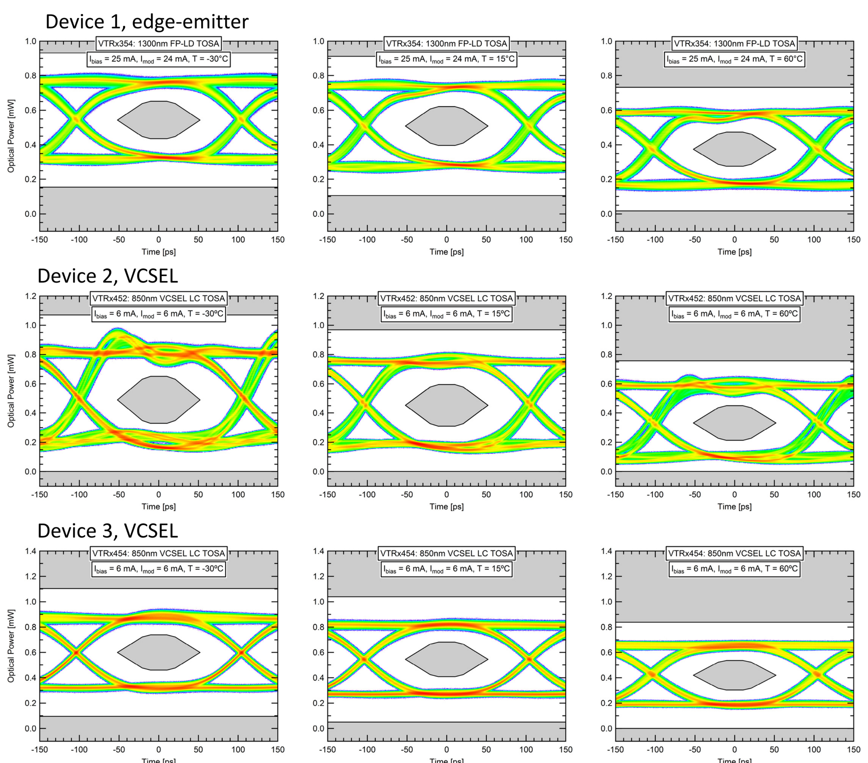
Static measurements, light-current and optical spectrum characteristics:
At each temperature step (ΔT = 15°C) the light-current curve and optical spectrum were measured. Only one single-mode edge-emitter TOSA was close to the slope efficiency limit. This was expected, because the prototype TOSAs were manufactured to looser tolerances than our specifications would allow. All other static parameters were within specified limits across the whole temperature range and behaved as expected when the temperature was changed. Device numbers from 1 to 3 present the TOSA manufacturers.

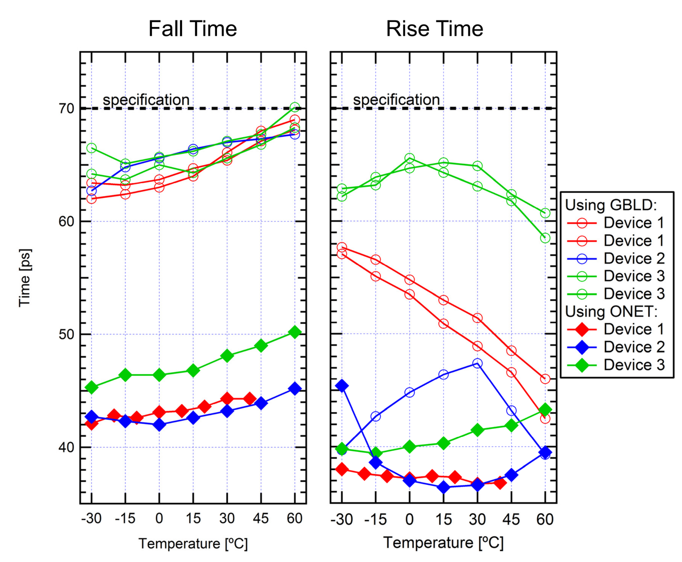


Dynamic measurements, eye diagram:

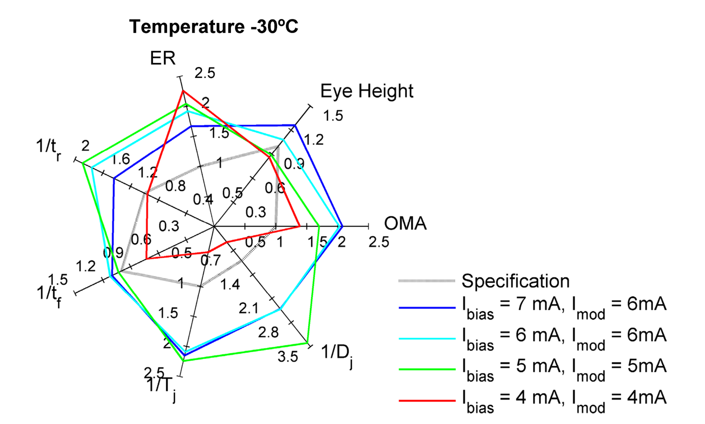
Eye diagrams were measured using several bias and modulation currents to find the optimal drive currents. Low currents are advantageous in terms of power consumption and reliability. For VCSELs the GBLD default values of I_{bias} = 6 mA and I_{mod} = 6 mA turned out to be optimal currents. Lower currents resulted in reduced eye height and optical modulation amplitude. Under- and overshoot also became a problem when low bias currents were used.

Optimal values for edge-emitters were I_{bias} = 25 mA and I_{mod} = 24 mA. Eye diagrams using these currents and normalized eye masks are shown on the right.

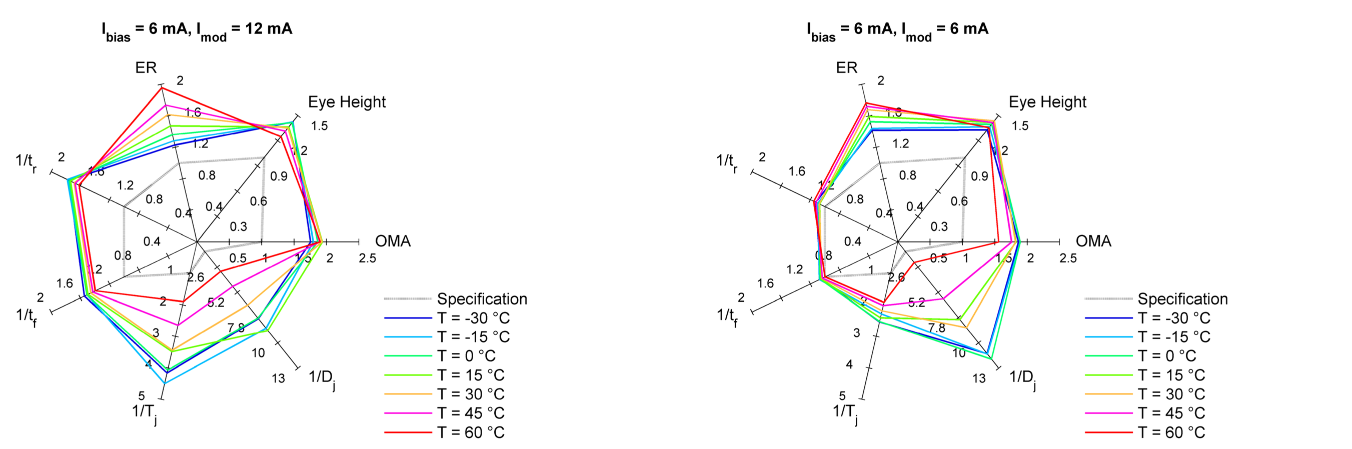




Rise and fall times were close to the specified limits. Especially at high temperatures fall times increased to the limit. A small improvement in fall and rise times can be seen when increasing pre/de emphasis at cost of high power consumption and large over/undershoot.



Device 2 using GBLD. Normalized dynamic parameters, specification = 1. Lowering the drive current decreases the eye height and optical modulation amplitude. Using low enough currents the overshoot and jitter increase dramatically.



Device 3. Normalized dynamic parameters. On the left device 3 is driven using a commercial laser driver and on the right using in-house GBLD. The main difference is in the timing parameters. Difference in modulation current is due to output stage of the commercial driver that acts like a current divider, reduction factor 0.5.

Conclusions

These tests prove that all TOSA and ROSA candidates are suitable for operation across a wide range of temperatures. Control measurements will be carried out to ensure the operation of the devices from different batches.

All measured TOSAs meet the specifications without any major differences, as long as bias and modulation currents are chosen correctly. The range of suitable currents is limited. Using recommended drive currents acceptable operation can be guaranteed across the whole temperature range. A wider range of currents can be used if the operation temperature is known, e.g. timing and jitter values improve at low temperatures, which allows lower bias and modulation currents.

Modules using the GBLD are slower for the same devices compared to modules using a commercial laser driver. Especially at high temperatures GBLD versions are close to rise and fall time limits. In every other category the performance of the GBLD versions is similar to their counterparts using commercial drivers.