SPACEFIBRE – HIGH SPEED FIBRE OPTIC DATA LINKS

Session: SpaceWire Components

Short Paper

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ABSTRACT

This paper describes development of two types of high performance fibre optic transmitter-receiver modules with optical fibre cables for SpaceFibre data links. Both solutions use mainly the same electrical and optoelectronic components but they have different mechanical designs. On type 1 transceiver electronics uses low temperature co-fired ceramic substrates (LTCC) and the module is hermetically sealed in Kovar housing. On type 2 an integrated ceramic package with fibre hermetic feed through has been developed in conjunction with a high performance optical sub assembly. On both types the transmitter is based on a 850nm GaAs Vertical Cavity Surface Emitting Lasers (VCSEL) and receiver part on a GaAs PIN photodiode.

1 INTRODUCTION

Emerging data rates on telecom satellites will require high through-put solutions for data transmission between e.g. antennas and data handling units. SpaceFibre is a proposed very high speed serial data link technology intended to complement the existing SpaceWire high-speed data link standard. This technique is based on opto-electronic transmitter and receiver modules with optical cables and connectors. Thus, two electronic units can be connected to each other with a high speed optical link.

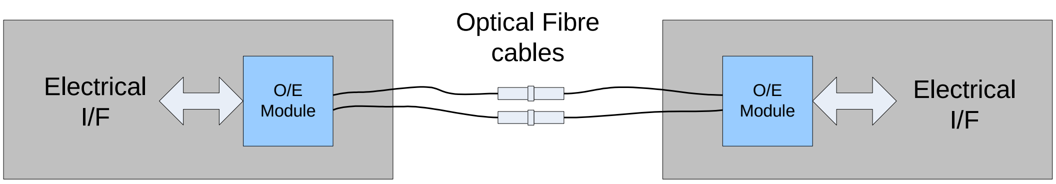

Fig. 1. Optical Link principle.

In the presented work we have developed two types of opto-electronic modules. VTT and D-Lightsys have both designed 10 Gbps optical transceivers suitable for the SpaceWire Protocol. For interoperability reasons, common mechanical dimensions, electrical pin layout and optical connector types were specified for the modules. The modules have max. outer dimensions of 17 x 17 x 5 mm^3 and is a 48-pin QFN type with 1mm pitch. A radiation resistant 50/125-µm 0.23NA graded-index fibre was selected for the transceiver pigtails. The outer diameter of the cabled pigtail is 1.2 mm and it is compatible with the Diamond Mini-AVIM, Diamond standard AVIM and Radiall LuxCis connectors.

2 MODULE DESIGNS

2.1 VTT'S TRANSCEIVERS

VTT employs low-temperature co-fired ceramic (LTCC) technology for the transceiver module electronics. Low conductor resistance and dielectric loss, multilayer structures with fine-line capability and compatibility with hermetic sealing make LTCC a useful technology for high-speed data communications. In addition, the good match of the thermal expansion coefficient to optoelectronic chips reduces packaging-induced thermomechanical stresses.

We decided to use 850-nm vertical cavity surface emitting lasers (VCSEL) as the light emitters. They offer low drive current and small power consumption. GaAs PIN diodes were chosen for the photodetectors. VCSELs and PIN diodes are bare dies compatible with flip-chip bonding.

Transceiver electronics is based on commercial 10 Gbps components and it consists of three boards: the mother board, transmitter optical subassembly (TOSA) and receiver optical subassembly (ROSA). The mother board contains the laser driver and interconnections between the subassemblies and current mode logic data inputs/outputs. TOSA contains the VCSEL and few passive components, and ROSA consists of the photo diode, receiver amplifier and few passives. The transceiver uses a single 3.3-V power supply and has a typical power consumption of 230 mW.

The maximum average transmitted optical power is limited to –0.67 dBm because of the eye safety limitations. The nominal sensitivity of the receiver at the photo detector is –18 dBm for 10^{-12} BER at 10 Gbps. Transceiver modules are hermetically sealed. This is realised with a metal lid and a Kovar frame soldered to the mother board, Fig. 2. The hermetic fibre feed-through is made using a low temperature glass preform. The transceiver module has dimensions of 17 × 17 × 5 mm^3 and a mass excluding the fibre pigtails of 4 grams. The pigtail cable weights 2.5 grams/meter.

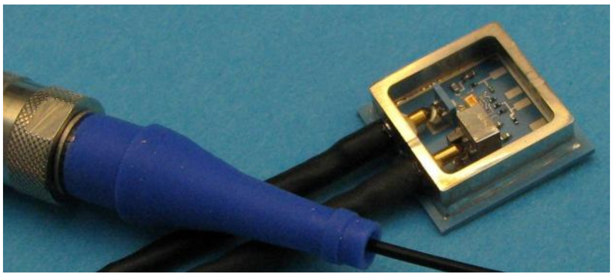

Fig. 2. VTT's SpaceFibre transceiver with LuxCis connectors before lid sealing.

2.2 D-LIGHTSYS'S TRANSCEIVERS

The module designed by D-Lightsys is realised with a HTCC ceramic substrate with a KOVAR wall and a low temperature glass feedthrough.

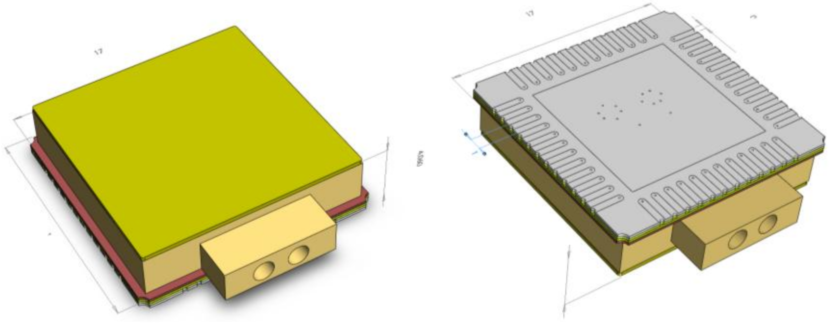

*FIG. 3 - HERMETIC CERAMIC PACKAGE (FRONT AND BOTTOM VIEW)*REFERENCES

D-Lightsys develop a unique Planar Optical Sub-Assembly (OSA) technology based on silicon micro machining. This silicon bench is used to precisely align the fibres (with +/-5µm accuracy) in front of the laser source and the photo detector chip to guarantee a coupling efficiency better than 80 to 90%.

The Optical Sub Assembly, is less than 2mm thick and have dimension of 6x6mm, allowing the integration of several laser source and detector manufacturers. The OSA is also responsible for the heat transfer within the package to allow the module to operate in the [-40;+85°C] temperature range.

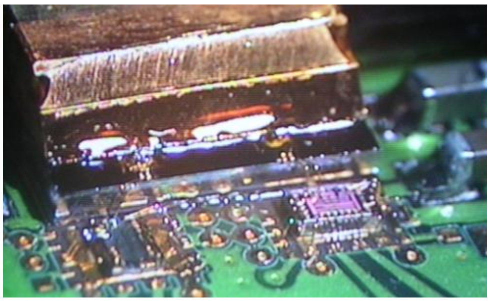

FIG. 4 – OPTICAL SUB-ASSEMBLY AND HIGH SPEED ELECTRONICS OVERVIEW

Laser driver and photodiode transimpedance/limiter amplifiers are hybridized within the hermetically sealed package with a controller to realize a protocol independent; temperature compensated high performance optical transceiver.

The module is designed to operate up to 10Gbps, with a 12dB link budget over the temperature range. D-Lightsys controller algorithm monitor in real-time the module status and temperature and compensate the laser modulation and biasing current accordingly. Less than 1dB of average optical power and less than 2dB of extinction ratio variation over temperature could be achieved.

3 PRELIMINARY TEST RESULTS

3.1 VTT'S MODULE : PRELIMINARY TEST RESULTS

Only the hermeticity test was performed for VTT modules at the time of issuing this paper. The results were positive and other test results were expected to be available soon after.

3.2 D-LIGHTSYS'S MODULE : PRELIMINARY TEST RESULTS

The following graph plots the evolution of the transceiver performances over the temperature range for bit rate of operation of 7Gbps.

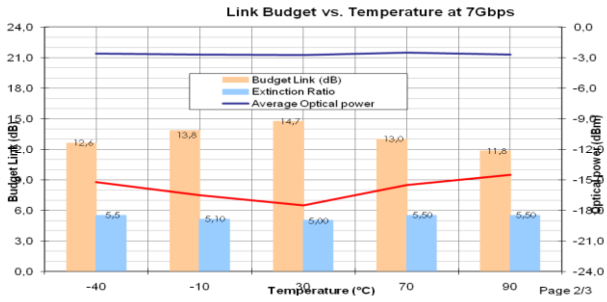

FIG. 5 – PRELIMINARY TEST RESULTS AND OPTICAL EYE DIAGRAM AT 90°C

A link budget better than 12dB could be achieved over the temperature range. The receiver sensitivity is slightly impacted with the temperature due to the test board substrate limitations (losses, reflexions, etc...). We provide hereafter the eye diagrams done a 90°C for the transmitter (optical eye) and -10°C for the receiver (Electrical Eye).

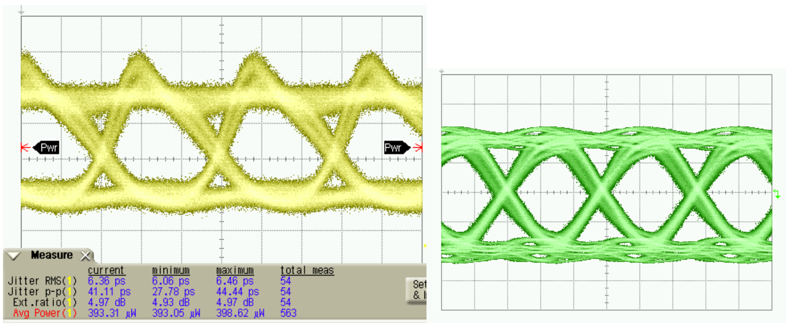

FIG. 6 – ELECTRICAL AND OPTICAL EYE DIAGRAM AT 7GBPS

3.3 RADIATION TESTS FOR COMPONENTS OF BOTH DESIGNS

Heavy Ion, protons and Gamma radiation tests have been performed within the scope of the project. Modules show good behaviour with a total Gamma dose of 100kRad and with proton radiation up to 1E12 protons/cm at a rate of 2E8 protons/cm2/s.

At Heavy Ions test up to LET threshold of 70 MeV/mg/cm2 only the VCSEL driver circuit showed to be latch up sensitive. Means to overcome this problem are being studied with the support of the components manufacturer.

4 CONCLUSION

Test results available so far are promising but more detailed testing will be required full characterisation of the developed optoelectronic modules.