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Overcoming the Challenges of the GigaDock® Transceiver Package

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This article gives first insights into the 3rd generation of short-range GigaDock® transceivers. Although the previous version has already found its way into a wide variety of markets, we do expect a decisive benefit from this new version. Hereby, the managing of existing constraints during processing and limitations in the optical performance motivated us for this step. This paper describes the actual development status and discusses the challenges, the reached level and the advantages, which are associated with the improved lens style. The optical characterization of the initial samples looks promising for later implementation in diverse customer applications.

Introduction

Light is an attractive medium for wireless communications because the spectrum is unlicensed compared to RF based solutions [1], enables high data rates and fulfills strong real-time demands [2]. Optical wireless communication (OWC) systems can address fields of applications, which go beyond niche markets. A good overview of activities in the OWC area can be found in [1]. Examples in the cm-range include the substitution of cables and connectors or the slip ring replacement at rotational machines for the communication between the rotor and the stator. Transceiver modules for short distances have been in our focus for more than a decade. Our in-house developments in this area are running under the brand name GigaDock®. A pair of such transceivers enables ultra-low latency, full-duplex data transmission over a distance of a few centimeters with data rates of multiple Gbps.

A short-range transceiver with monolithic optic has been presented in 2018 [2]. The small scale design of this transceiver version ‘V1’ already aimed at the replacement of rotary connectors. The main advancement of the follow-up type ‘V2’ consisted in the first-time solderability by a machine soldering process with adjusted temperature profile [3]. Type ‘V2’ transceivers found (and find) entrance in diverse applications. For example, they are in use as key element in the optical data interface for the intra-satellite-communication [4]. These transceivers are highly reliable and provide flexibility in terms of transfer rates and protocols. The practical test at the International Space Station (ISS) took place in 2022 [5]. Starting from type ‘V2’, there are still opportunities for improvement in terms of form factor or temperature sensitivity which led to the development of variant ‘V3’. Its current state shall be reviewed more in detail below.

Lens Design

Like the previous versions, the conceived lens is designed as a Fresnel lens, but now with a significant reduction of volume and mass. The intra-lens optical path length has been drastically reduced which results in less optical loss inside the transceiver. The beam guidance occurs close to the axis of beam propagation, which keeps the losses outside the transceiver small. Fig. 1 shows the new transceiver in relation to the previous versions.

(a) (b) (c)

Fig. 1 (a) Former transceiver V1. (b) Current design V2. (c) New transceiver V3.

Processing Capability

A lower lens thickness enables a smaller overall height of the transceiver module. While the transceivers 'V1' and 'V2' still have a height of 5 mm, this was reduced to less than 3 mm for the new type 'V3'. That has an advantageous effect on the manufacturability. Moreover, the transceivers can move closer together at the place of installation, if required.

Another often requested feature by the customer concerns the solderability. Lead-free reflow soldering according to IPC/ JEDEC J-STD-020 [6] means a short term thermal load of 260 °C for the device. The transceiver 'V2' withstands a maximum temperature of 200 °C which excludes the use of common Sn-Ag-Cu-soldering pastes. The temperature stability of the new transceiver generation 'V3' is now improved by 45 K. An adjustment of the soldering profile via a reduction of the peak temperature by 15 K and adaption of the time periods is still necessary. Nevertheless, the 260 °C-target is close and should be feasible using an even more thermo-stable lens material.

The transceiver itself is a surface mountable device (SMD) with a regular pin pitch of 500 µm at the edges of the transceiver bottom. Thereby, the footprint corresponds to a standard quad-flat no-leads (QFN) component.

Optical Characterization

First samples of the new transceiver generation have been realized. This was followed by a detailed optical characterization. A pair of transceivers were mounted on supply boards and further on a linear test stage, as shown in Fig. 2a. As a result, one gets knowledge about the acceptable displacement range of that transceiver pair. An alignment plot is depicted in Fig. 2b. The aim is to achieve a bit error rate (BER) value of 1E-09 with as much as possible displacement range. The allowable misalignment of a transceiver pair depends on different factors like the selected data rate and the optical power. Tests have been carried out at 1 Gbps and 5 Gbps. Another parameter is the distance between the transceivers. A typical reference distance is 35 mm.

The transceiver works at a wavelength of 850 nm. The measurement result from Fig. 2b was received under the conditions of laser class 1. The minimal BER requirement of 1E-09 at 5 Gbps is almost entirely fulfilled inside the inner black circle which allows a xy-misalignment of up to 1 mm. In the future, 2 mm should also be possible what is indicated by the outer circle. A significant extension of the alignment could be achieved by an increase of the optical power. There is a similar behavior for the communication distance in the case of different optical power levels. But this improvement due to higher optical power is only an option if one can house the transceivers to prevent the restrictions of a laser class 3R.

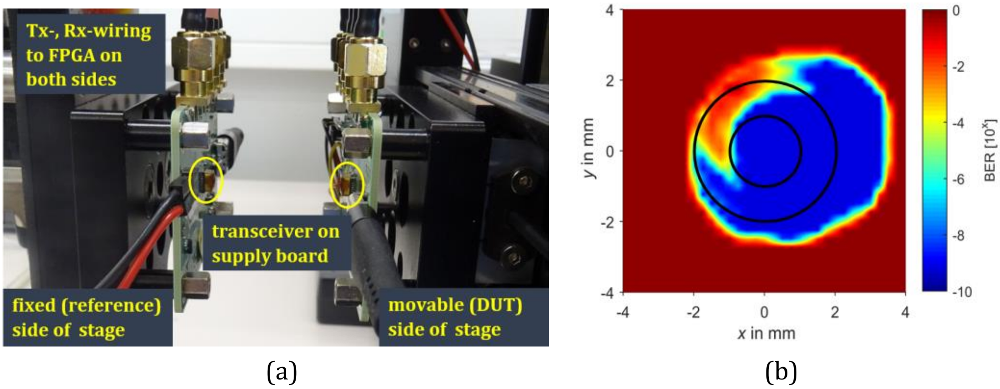

Fig. 2. a) Sectional view of the setup for BER-measurement.
b) BER-plot at a data rate of 5Gbps at a distance of 35mm.

Conclusion and Prospects

A new transceiver design with a clearly reduced overall height by 40 % was presented. From this, we expect to get a better processability. First samples have been assembled and characterized. The obtained results make us optimistic that this transceiver design can also convince customers and open up new fields of applications. In the meantime, further samples will be realized. It is necessary to improve the alignment tolerances and their symmetrical arrangement.

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