BIDIRECTIONAL LINK MOCK-UP FOR AVIONICS APPLICATIONS

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Introduction

Copper-based networks have been extensively employed on aircraft to ensure the avionics data-communications. Since the Airbus A380 development, Avionic Data Communication Network (ADCN) has been implemented to ensure transmissions between avionic equipment. This ADCN is based on the Avionic Full Duplex Ethernet (AFDX) technology, and transfers data at rates up to 100 Mb/s. The need of faster communications systems, up to 1Gb/s, has led to great interest in fiber optic based networks. Beyond higher data rates capabilities, the fiber optics have additional benefits, compared to electrical cables, in terms of weight saving and electromagnetic interference immunity which is strongly needed at gigahertz bandwidths. Multimode fibers (MMF) are becoming increasingly attractive for short-distance (<300m) high-speed interconnections. Besides, Vertical Cavity Surface Emitting Lasers (VCSELs) present interesting performances in comparison to edge-emitting lasers. In addition, VCSELs are cost effective and widely chosen in this type of interconnections. Given all these capabilities, we aim at achieving an entirely optical fiber Gigabit Ethernet (GbE) link based on 850nm VCSELs to interconnect avionic equipment. To meet ADCN requirements [1] based on IEEE 802.3 standards [2], the optical link must be full-duplex, bi-directional, on a single wavelength, and on the same fiber, with 100m-span. We have built a mock-up of the described optical link. At each side, we have employed a transceiver module developed for harsh environment applications. Also, there are multiple connections due to "production breaks". These connections give birth to return loss (RL) and consequently crosstalk. One might pay attention to the impact of the RL on the link. We present the characterization of the mock-up and validation of the experimental results according to GbE requirements.

Link Components Description

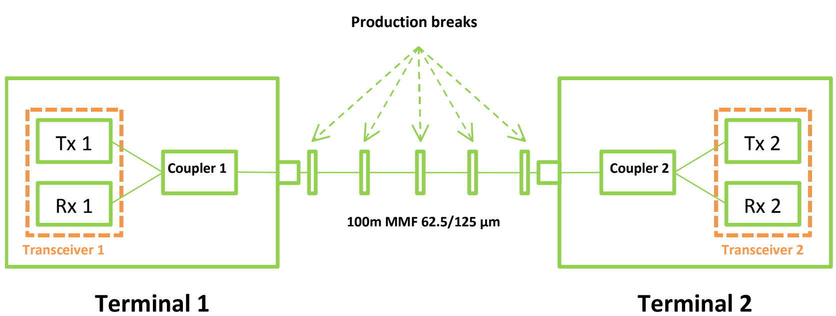

Figure 1. Schematic block diagram of the full-duplex link

D-Lightsys Transceiver

At each terminal (Figure 1), we plug a transceiver, integrating a 850nm VCSEL, a GaAs PIN photodiode and a CMOS electronics. The modules are designed for short distance Datacoms and to support harsh environments [3]. The optical interface is composed of 2 pigtails (MMF). The modules operate at 1.25Gp/s for the characterization.

100m fiber optic link

The link is composed of an avionic standardized graded index MMF, *62.5/125µm* and takes into account the "production breaks". ELIO-connectors form the termination at the end of each section (figure 1). Five connector breaks are employed, assembling 5 segments of 20m each. The fibers and ELIO-connectors are used to build the 100m-link, representative of a real aircraft-type application. Two Additional *1m* fibers are used to connect the link to each terminal. To achieve transmission on a single MMF fiber, we use a 50/50 coupler.

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Performances Testing

We describe here the performance of the bidirectional and full-duplex digital link presented above and modulated at *1.25 Gb/s* by a pseudo-random bit sequence (PRBS) of 2^7-*1* length. All the measurements are taken at room-temperature. The output power of the transceivers #1 and #2 is measured: P_{e1}=*-1.0 dBm* and P_{e2}=*-2.0 dBm.* These optical power values are below eye safety (0 *dBm*). Their sensitivities at BER 10^{-12} are S_1=*-21.8 dBm* and *-21.9 dBm*, respectively, corresponding to the power budget of each channel of *20.8 dB* and *19.9 dB*. The available power budget on a 100m-avionic link must include losses due to the production breaks, installation, repair provision, ageing, and more traditionally, the connectors, couplers and fiber length. Measured return loss (RL) equals *18 dB*. In comparison with GbE standards, the minimum RL required is: RL_{GbE} *(min)=12dB* [2]. Jitter and rise/fall time (Table 1) values are compatible with the IEEE requirements : *deterministic jitter=370 ps*, *total jitter=599 ps* and T_{rise}/T_{fall}*=260 ps.* And, for the receiver sensitivity, the GbE IEEE specification is *–17dBm* [2].

Table 1. Performances at 1.25 Gb/s (Rx of modules #1 & #2)

Module	#1	#2
RMS jitter (ps)	*20.11*	*13.46*
Pk-Pk jitter (ps)	*115.0*	*80.5*
Rise time (ps)	*156.4*	*105.8*
Fall time (ps)	*133.4*	*82.8*
Pin Tx (dBm)	*-1.0*	*-2.0*
Pin Rx (dBm)	*-16.5*	*-12*

The eye diagrams of optical link described here are shown if Figure 2. For channel #1, the eye diagram, displayed on figure 2-a, is compared to GbE mask on figure 2-b. The 2 channels of full-duplex GbE transmission are shown on figure 2-c.

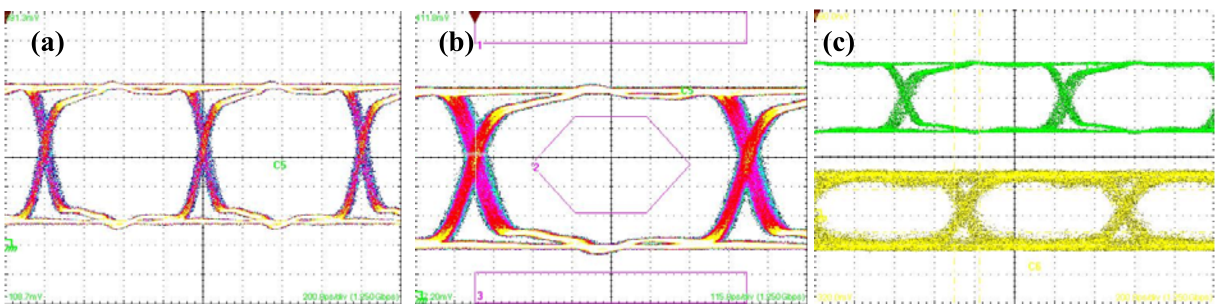

Figure 2. Channel 1→2 : 1.25 Gb/s Receiver eye diagram : (a-b) Transceiver 1 signal and comparison with GbE mask; (c) Bidirectional link eye diagrams of transceiver #1 *(Top)* **and #2** *(bottom)*

Conclusion

We demonstrated an avionic-representative link at 1 Gb/s with a span of 100m. The performances are compliant with IEEE GbE specifications and tolerant to "production breaks". In order to validate the reliability of this solution, additional connectors influence on the link performances need to be checked. Also, temperature in the [-40, +85°C] range, and vibrations constrains need to be tested. At term, we expect the transceiver to be improved to include the MMF coupling function, which will help controlling the return losses. Avionic standards, namely ARINC 800 requirements, shall finally be taken into account in link specification.

References

[1] ARINC 664, part 2.

[2] IEEE 802.3-2002, section 3, Clause 38.

[3] M. Pez, F. Quentel, G. Barbary, C. Claudepierre, C. Hartmann, "High performance Mil/Aero Fiber Optic Transceiver", *IEEE Avionics Fiber-Optics and Photonics Conference*, pp. 37-38, 2005.