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 system is based on the Avionic Full Duplex Ethernet (AFDX), 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-haul (<300m) high-speed interconnections. Besides, Vertical Cavity Surface Emitting Lasers (VCSELs) present interesting performances in comparison to edge-emitting lasers, are cost effective and widely chosen in this type of applications. We aim at achieving an entirely optical fiber Gigabit Ethernet (GbE) link based on 850nm VCSELs to interconnect avionic equipments. To meet IEEE 802.3 standards [1] and ADCN requirements [2], the fiber optic link must be full-duplex, bi-directional, on a single wavelength, and on the same fiber, with 100m-span. We have employed, at each side of the link, 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 a mock-up and the comparison of experimental results with the GbE requirements.

Link Components Description

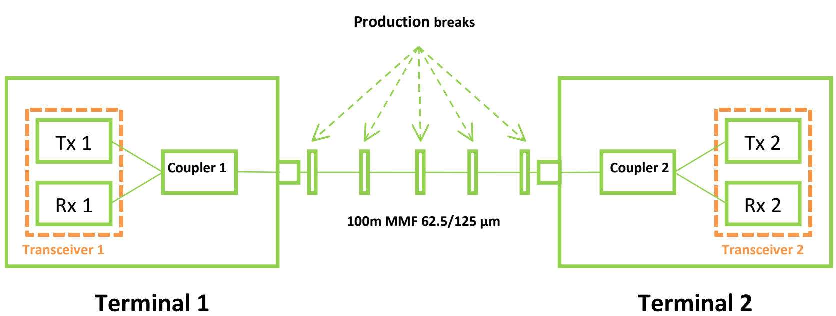


Figure 1. Schematic block diagram of the full-duplex link

D-Lightsys Transceiver

At each terminal (Figure 1), we plug a transceiver, integrating a 850nm VCSEL, an 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 harness is composed of an avionic standardized graded index multimode fiber, 62.5/125µm and takes into account the "production breaks" on the link. ELIO connectors formed the termination at the end of each section (figure 1). Five connector breaks are used, assembling 5 harness sections, of 20m each. The fibers and ELIO-connectors are used to build the 100m-harness, representative of a real aircraft-type application. Two Additional 1m fibers were used to connect the whole link to each terminal. To achieve transmission on a single MMF fiber, a 50/50 coupler is used.

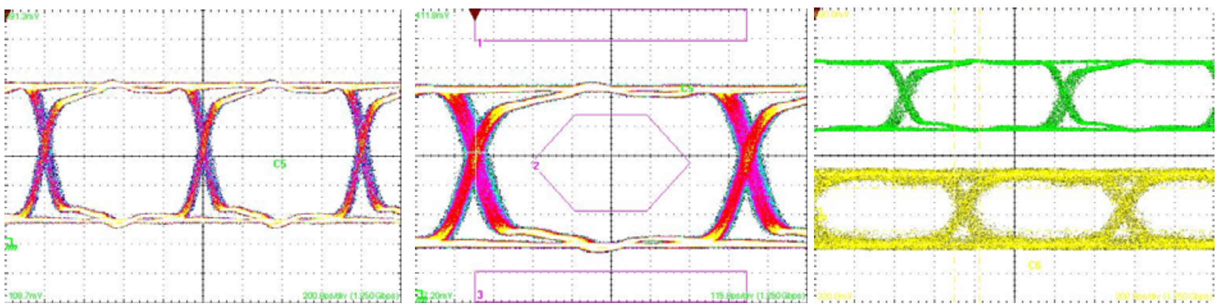
Performances Testing

In this section, we describe 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*. The output power of the transceivers #1 and 2 is measured: P_{e1}=*-1.0 dBm* and P_{e2} = *-2.0 dB m*. 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 power budget of each channel of *20.8 dB* and *19.9 dB*. The available power budget is greater than *15 dB*, which is the specification of minimum power budget on a 100m-avionic link, including 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) =12 dB* [1]. Jitter and rise/fall time (Table 1) values are compatible with the IEEE requirements : Deterministic jitter=370 ps and Total jitter = 599 ps [1].

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 is shown on figure 2-c.



(a) **(b)** **(c)**

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

Conclusion

The measurements in this paper were taken at room temperature. We compared measurement results with the GbE specifications. In order to demonstrate the reliability of the bi-directional and full-duplex solution, temperature and vibration tests will be mandatory. At term, we expect the transceiver to be improved to include the MMF coupling function, which will helps controlling the return losses. Avionic standards, namely ARINC 800 requirements, shall finally be taken into account in link specification.

References

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

[2] ARINC 664, part 7.

[3] M. Pez, F. Quentel, G. Barbary, C. Claudepierre, C. Hartmann, *"High performance Mil/Aero Fiber Optic Transceiver*", Avionics Fiber-Optics and Photonics, 2005. IEEE Conference, 20-22 Sept. 2005 Page(s):37 – 38.