Qualification of the optical links for the data readout in LHCb

LHCB Technical Note

Issue: Draft
Revision: 1

Reference: LHCB xxxxx
Created: 28th Jan 2005
Last modified: 11th Dec 1997

Prepared By: V. Bobillier

Abstract

This document describes the series of tests to be done in order to qualify the optical links for the data readout of LHCb. The goal of these tests is to determine the power budget of the data readout system formed by the transmitter on the detectors side and the optical receiver card to be plugged on the TELL1 board.

Document Status Sheet

Table 1 Document Status Sheet

1. Document Title: [Project Name Qualification] User Requirements Document			
2. Document Reference Number: [Document Reference Number]			
3. Issue	**4. Revision**	**5. Date**	**6. Reason for change**
Draft	1	28 Jan 05	First version

Table of Contents

1. Introduction

In LHCb, most of the data transportations, from the sub-detector front-end to the TELL1 boards in the counting house, are done via optical links. A total of about 7200 optical links is foreseen to be installed in the LHCb experiment for the data readout. This amount of optical links to be installed implies that serious qualification process must be made before the optical cables are ordered. In addition, the power budget the transmitter receiver pair offers must be determined precisely in order to quantify the power margin available in the final system.

2. Tests to be performed

The tests that have to be done can be broken in two different parts. The first one consists of qualifying the optical links by measuring the total power loss of them. The second step is to determine the power budget available in the readout system. This last test mainly consists of measuring the bit error rate while increasing the power attenuation present in the optical link.

2.1. Power loss of the optical link

The goal of measuring the power loss of an entire optical link is to qualify the optical cables and connectors. The full optical link is made of a number of patch cord cables, ribbon cables, connectors, patch panels and splitting cassettes and cables. The number of those different equipments depends on the configuration of the link and of the users needs (splitting, redistribution, etc.).

The power loss test simply consists of sending a known power source on one end of the tested link while measuring the power received on the other end. Some care has to be taken before and during this measurement. The first thing to be looked at before doing any tests and in general before using an optical link is the cleanliness of the optical connectors and make sure they are protected by caps when not used [1]. Dirty connectors are the principal source of troubles with optical links. For accurate measurements, it is recommended to mandrel wrapping the first length of optical fiber at the power source end. This offers the advantage of getting rid of the high-order modes that can appear in the core of the optical fiber when optical test power sources are used. These high-order modes distort the measurements because they are not present when a standard transmitter is used [2].

The test procedure begins with determining the loss of the jumper (or patch cord) cables to be used to connect the measurement instruments to the system under test [3]. Then the entire system, including the patch cords, cables, patch panels, splitting cables, can be measured. The loss usually induced by the matting is of the order of 0.5 dBm. If the measurements show a result completely out of this order of magnitude, the cleanliness of the connectors should be verified. Bending radius of fiber cables plays an important role in the power loss of a given link. Therefore, when the power loss of a given link is measured, the bending number and radius to be applied on the cable should be representative of how the cable path will force the cable to bend in the final layout. The test procedure to be followed for measuring optical fiber cables should be the one given in [3].

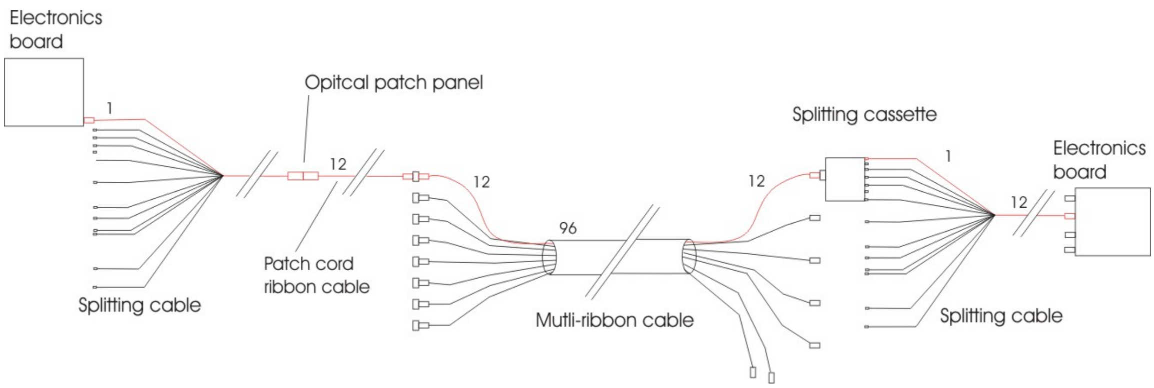

Figure 1: Layout of a typical optical link with splitted parts for load repartition.

2.2. Power budget measurement

The power budget of a given optical link is function of the output power of the transmitter and the sensitivity of the receiver. When the power margin of a given optical link has reached a certain low level limit, the link is not frankly lost but the bit error rate (BER) is increased significantly.

To determine the power budget of a given optical system, the bit error rate at the receiver end must be measured and the maximum BER limit must be determined in advance. Then, an optical link (with a known power loss) should be used for the data readout between the transmitter and the receiver and a configurable attenuator must be introduced in the link. The bit error rate must be measured while the power loss introduced by the attenuator is increased step by step. The optical pattern generator (OPG) [4], simulating the detector front-end and a TELL1 [5] board are used for the measurement. The TELL1 board should be able to give the BER as an output. This BER is measured by comparing the data received via the optical link to the ones sent by the OPG. The data patterns sent by the OPG to the TELL1 can be downloaded via Telnet (later PVSS).

The optical pattern generator has been made to send a known and as much as possible representative data pattern via an optical transmitter. Two sets of FPGA, GOL and 12 channels optical transmitter are available on the optical pattern generator board. This means that one pattern generator perfectly fits one TELL1 board. The same output signal from the GOL chip is used to drive the 12 inputs of the optical transmitter.

For the power budget measurement, the data pattern to be used does not play a key role since the GOL chip DC-balance the signal that is given on the input of the optical transmitter. During the measurement, only one of the twelve fibers of a ribbon cable can be attenuated while the BER is measured on the TELL1 board by comparing what is received by the other fiber links. A comparison should also be possible with the pattern that is really sent by the OPG by checking this via Telnet or PVSS, this in order to avoid any additional bit error provoked by something else than the optical link.

In situ error checking:

As described in the Requirements to the L1 front-end electronics [6], a continuous error checking must be implemented at the Level 1 stage. This would in principle give the possibility to detect a partially broken link when repetitive errors occur somewhere. In addition to that, the TLK2501 deserialiser chip has a “receive data valid” output that indicates if the received and decoded datas are valid or not.

2.3. Test on optical fibers with OTDR

OTDR, optical time domain reflectometer, allows an accurate analysis of optical fiber links. An OTDR is available at CERN and is to be shared by the different experiments when needed. OTDR measurement procures a representation of the entire optical link and can show precisely where a problem or another might come from.

3. References

[1] Handling guidelines for optical fibers in LHCb…

[2] Corning engineering note number 68 rev. 2: Improving multimode fiber testing accuracy with mandrel wrapping:

[3] Corning engineering note number 78 rev. 1: Field test procedure for measuring optical power loss of MTP links: http://www.corningcablesystems.com/web/college/college.nsf/ehtml/index

[4] Optical Pattern Generator card document

[5] TELL1 mother board document

[6] LHCb 2003-078, Requirements to the L1 front-end electronics (pdf or word)