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The TOB rod functional test

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Abstract

This document describes the testing procedure for rods after cabling and after the electrical connectivity test. It's main purpose is to instruct the people that are cabling rods at CERN in building 596 to perform all the necessary tests, interpret test results and qualify all rods in order to ship fully functional cabled rods to the US production sites at Fermilab and UCSB in the US.

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1 Introduction

TOB rods are being produced in several steps. Rod frames are being produced at Helsinki Institute of Physics and shipped to CERN. At CERN, the rod connectivity electronics (interconnect bus, interconnect cards, optohybrids, and CCUM) is being mounted on the frames and tested. Functional rods are then shipped to Fermilab or University of California in Santa Barbara, where modules are mounted and more tests are performed. Rods are then shipped back to CERN and after another test integrated into the TOB wheel. This document describes the functional test, one of the two tests that is performed during rod cabling at CERN.

The electrical test ensures pin-to-pin connectivity and excludes shorts. It is performed before the CCUM is being mounted on the rod. This means that another test after all components are placed is necessary. This includes testing the full data chain, which has not been tested before. Although all components of the rod have passed several tests in advance, some errors could still remain undetected, e.g. damages introduced during handling or through discharges of static electricity. Fibers could be wrongly placed in the connector, and optohybrids not working or working outside specifications. Before shipping the fully cabled rods to the integration centers in the US, one has to make sure that the rod is fully functional. Therefore the TOB Rod Functional Test aims at delivering only fully functional cabled rod frames.

2 The test setup

The setup for the rod functional test is shown in Figure 1. The rod is being fixed in a rod rotating support to allow easy mounting of hybrids and connectors. The rod receives power on the 1.25 V and 2.5 V lines from a CMS Tracker Test Power supply. The control ring is electric, with a FEC2CCUM card and an adapter card. The FEC2CCUM card is powered by the same power supply. Only one rod is connected to the control ring at a time. The ring is controlled by a FEC that resides in a PC close to the setup. The PC will steer the control ring and initialize all the hardware and front end devices. At the same time, the PC also serves for data acquisition. The optical ribbons that transport the data coming from the analog opto-hybrids are removed from the fiber holder and plugged into one test ribbon for SS4 rods, and two test ribbons for SS6 and DS rods. Those ribbons end in two OEC, and their electrical output is partly fed into the Karlsruhe multiplexer. The output of the Karlsruhe multiplexer as well as the first two data channels of each OEC are connected directly to the FED. FED and FEC receive clock and trigger pulses from a TSC card. A functional test program, which is based on XROD [**?**], has been developped to perform the functional test of the rods, initializing all the hardware and controlling the test procedure.

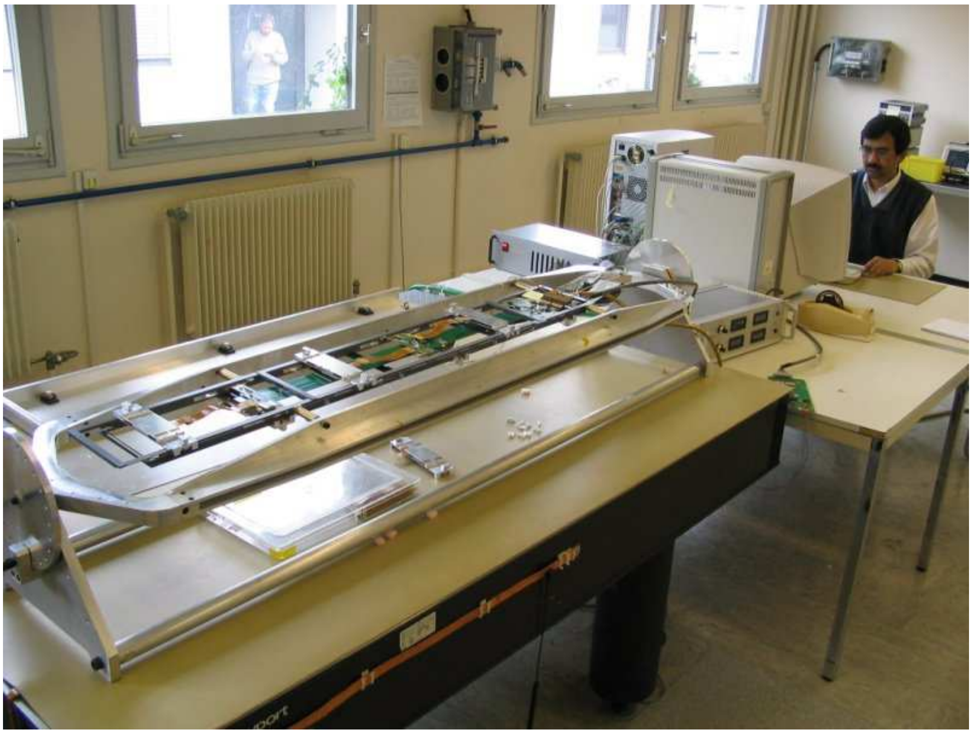

Figure 1: The rod functional test setup in building 596 at CERN.

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3 Test procedure

A fully automatic procedure is used, where the user is only able to start or interrupt the test. The result of this test is either positive or negative. If the test turns out to be positive, the tested rod can be shipped to the module integration center in the US. If the test fails, the reason for the failure is given to allow for a repair, and the test can be started again. After the test, a report is created and stored for later retrieval. For each test, new data files and reports are generated that can be identified by a sequence number. Thus the full history of a rod is available.

The user starts the test procedure by pressing the ”Start quick test” button in the Production Test page. After starting, the test can be stopped at any stage by pressing the ”Stop any test” button. In this case, the result of the test is a failure. The quick test takes about two minutes, and 200 data events are recorded for each optohybrid. After a succesfull quick test and as long as the rod can stay at the setup, a long test is performed. It is started by pressing the “Start long test” button. It will run forever, unless stopped by the “Stop any test” button. If stopped, the data that has been taken is analyzed and the test result displayed.

3.1 Database verification

After pressing one of the two start buttons, the user has to scan the rod barcode with help of the attached DENSO 2d barcode scanner. Once the barcode is being read, it is stored in the GUI interface and for a following test of the same rod, does not need to be scanned a second time.

After scanning the barcode, the barcode is being verified against the Tracker construction Database. If the barcode is wrong, the test fails and stops. If the barcode is found in the database, a hardware configuration based on the description in the construction database is generated. This takes different settings for the CCUM address as well as different addresses and number of frontend chips for SS4, SS6 and DS rods into account. The hardware is initialized according to the configuration in the database. If there are errors during initialization, which could originate e.g. from wrong entries in the database, the test stops and fails, notifying the user about errors during the hardware access. This could also originate if some of the components are not placed correctly, e.g. the if the CCUM is not plugged in correctly, resulting in bad electrical connectivity to the IC BUS. This could still be possible since this has not been tested before.

3.2 Test of the DCU sensing lines on the CCUM

The electrical test verifies the continuity of the sensing lines for the sensing of the 1.25 V and 2.5 V power on the rod. In principle still an error could occur in the connection of the CCUM to the rod. To verify that this is not the case, the DCU is being read and the values are compared to the allowed range. If one of the values is not within limits, an error is reported and the test fails and stops.

3.3 CCUM identification and DCU calibration

After access to the hardware has succeeded, the DCU key of the CCUM is read. This key serves as a unique key to the CCUM and can be used to identify the CCUM (and thus the rod) by reading it through the control loop. The connection between the CCUM barcode, the rod barcode and the DCU key is now being established and saved in the Tracker Construction Database. Additionally, the DCU calibration data are stored in the database and connected to the barcodes in the same fashion.

3.4 I^2C connectivity and functional test

Before data is being taken, the I^2C lines of the Interconnect Bus and the presence of all components (optohybrids and readout hybrids) is verified.

In a first step, bias and gain registers of all optohybrids are being set and read on each I^2C line. If the same value is being read as it was set, the I^2C line and the registers are reported to be functional. If any of the read values differs from the set value, the test fails and a report on where the failure occurred is being printed.

In a similar way the presence of the readout hybrids is verified: The DCU test register on each hybrid is accessed and a value is being read. If the transaction is successful, the hybrid is assumed to be working. The APV and MUX chips on the hybrid are not accessed, since the main purpose of this test is to ensure that the hybrid has been connected; it is not intended to be a functional test of the readout hybrid.

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Under certain circumstances which are described in another CMS internal note (*to be written!*), using the capton test tails as it is done in the functional test setup, certain I2C patterns can make the APV chip on the readout hybrid to believe it is being addressed, although this is not the case.

This can result in either corrupted settings in the I^2C slave registers (e.g. analog optohybrid or the APV itself) or failing communication. In either way, data that is sent over the analog link to the front end driver may be corrupted.

To test whether also production rods are being affected by these problems, the functional test issues test sequences that have caused problems on the I^2C lines and tries to determine existing problems. If a problem is encountered, the test fails and gives a warning message on which location the test was failing.

3.5 Verification of the fiber routing

After the communication test succeeds, the hardware is initialized for data taking. This includes scanning the tick marks of the APV header in FED scope mode to determine their position in the FED ADC range, to be able to set thresholds for the FED running in header finding mode (see the FED manual for details).

After setting up data taking, the routing of the fibres is verified. All lasers are switched off. Then, for each laser on each optohybrid under study, the laser is switched on and FED samples are being taken. If the data from this laser is not in the position where it should have been observed, the user is informed about the wrongly configured position in the GUI. Then the laser is switched off again, and the procedure repeats with the next laser. After all lasers have been checked, the test is evaluated. If one or more fibers are not connected in the right place, the test stops and fails.

3.6 Data taking

If all the above tests succeed, data taking will start. As a first step, the testing procedure enables the program to save the raw data to ROOT streaming files. The hardware will be set into a mode where the TSC sends triggers with a constant frequency to the frontend hybrids and the FED, which will send and sample the data, respectively. Since not all data channels can be read at a time, after a certain number of events a different input channel will be automatically selected by switching the Karlsruhe multiplexer to take data from another channel. In the production test program, the setting of the multiplexer will be taken automatically into account, and the data will be correctly assigned to the source of this channel.

After data has been taken from all channels, data taking stops, the data is saved to a ROOT file, and the analysis phase is started.

3.7 Data analysis

All optohybrids are set during data taking to gain 1 and bias 25. The distribution of the laser power is known for those values and is shown in figure **??**. Taking into account the optical gain of the optical chain of the functional test setup, this distribution is converted into an expectation on the ADC range that will be observed in the FED.

A process is started that analyzes the previously taken data. Each opto-hybrid channel will be checked if data is being transmitted. If this is not the case, a message is printed and the test fails. Even although it will fail, all channels will be checked in order to give a full analysis of the rod.

Additionally the opto-hybrid will be checked for reasonable light yield, comparing the measured ADC range to the expected range. This is done by looking at maximum and minimum height of the digitized data. This height corresponds directly to the light yield of the AOH. Cuts have been set to reflect the design parameters of the AOH.

After all these test have been performed, a report is generated that states success or failure of an opto-hybrid and the reason why (light yield, no output). This report is saved to disk and stored for later retrieval. Additionally, the distribution of the light yield (minimum and maximum of the laser ADC range and their difference) are plotted and saved in a file. Before the test is finished, the users has to look at those distributions and acknowledge the test result.

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