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CMS Optical Links - Lessons learned from Mass Production

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The CMS Tracker will install over 40000 optical links in its data readout and control system, representing an unprecedented deployment of this technology in a Particle Physics Experiment. After reviewing the Quality process employed in this project, a summary of the performance data measured during production will be shown. The analysis of this data will then be used to illustrate how the performance of the installed system may be predicted, giving confidence that the specified functionality will be attained in the final system. Completion of the production has allowed reflection upon the processes used and improvements for future such projects will be given in the form of some lessons learned.

Summary

Production of components for the 40000 optical links of the data readout and control system of the CMS Tracker is now complete. The Quality Assurance process put in place for the production yielded detailed performance data for each individual component produced. The QA process put in place before component-production started will be outlined. For such an unprecedented (in the field of Particle Physics) scale of production all components were produced by industrial partners. This was made possible through the choice of COTS-based components with only minimal modification to meet the criteria set by the CMS Tracker environment. Production proceeded in batches, with the manufacturers providing per-device measurements of the key performance parameters with delivery of the batch. Batch-level acceptance was then carried out at CERN to verify these measurements.
The large number of components produced has yielded a unique data set of component performance that can be used to make statistical predictions on the overall performance of the links that will be installed in CMS. Analysis of this data will be presented, showing on the one hand the progression of production from start to finish and highlighting the issues that occurred along the way; and on the other hand giving data that can be used to predict the performance margins of the installed links. For the analogue readout system of the CMS Tracker the gain of the individual links is of utmost importance, since it directly affects the overall dynamic range of the full readout chain. It will be shown that the final performance dataset confirms the prediction that all links will enable data to be transmitted with sufficient margin. For the digital control system that is based upon the same components as the analogue readout system these data allow the confirmation of the operating margins.
We will also reflect upon the progression of the production and the problems encountered along the way. The most critical phase of the process for all components was the start-up phase during which the manufacturing process was qualified by CERN. It was in this phase that the largest number of issues had to be resolved so that the production could then proceed smoothly to the end. We will conclude by providing some lessons learned for future projects of this scale.

Author: TROSKA, Jan (CERN)

Co-authors: Mr RICCI, Daniel (INFN Perugia); Dr VASEY, Francois (CERN); Dr GILL, Karl (CERN); Mr GRABIT, Robert (CERN); Mr DRIS, Stefanos (CERN and Imperial College, London)

Presenter: TROSKA, Jan (CERN)

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