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Reduction of constraints in the specification for the Hybrid circuit procurement for the CMS Phase-2 Upgrade

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Abstract
New sensor modules are currently being produced for the Tracker in the CMS Phase-2 Upgrade. These Strip-Strip and Pixel-Strip modules are the two main building blocks of the Outer Tracker. All together 8000 Strip-Strip and 5880 Pixel-Strip modules will be constructed and their construction requires the mass production of 47520 hybrid circuits. Despite careful preparation of the specifications for the hybrid circuit manufacturing, real production experience demonstrated the need to reduce and optimize some of the requirements. The presentation will focus on two example cases where the original requirements were analysed and reduced while still fulfilling the project requirements.

Summary (500 words)

All together 47520 hybrid circuits will be manufactured for the total construction of 13880 Strip-Strip (2S) and Pixel-Strip (PS) sensor modules. The two module types are both consisting of two planar silicon sensors. In both module types this sensor sandwich is interconnected to the Front-end hybrids by the means of wire-bonds. The main function of the Front-end hybrids is to collect and process the hits generated by the particles passing through the silicon sensors. The Front-end hybrids have high-speed digital signals routed to the Service or Readout hybrids to pass the digitized data to the serializer ASIC that transmits this data through a high-speed optical link to the back-end systems.

In order to ensure the correct and reliable operation of the electronics and a smooth module assembly, strict specifications were created for the procurement contracts. A strict quality control procedure was implemented at CERN to control these requirements. In the original specification, in accordance with the usual practice in High Energy Physics experiments, it was required that the wire-bond pads must not have any kind of visible contamination with 60x magnification under regular and polarized lighting conditions.

However, the supplier of the hybrid circuits had difficulties to meet the quality that was defined in the specification. Despite the very serious efforts from both the bare circuit supplier and the circuit assembler, the production yield was greatly affected by the losses due to the contaminated wire-bond pads. According to the original specification even a very small imperfection on just 5 wire bond pads out of the more than 2000 wire bond pads per circuit could lead to the rejection of a front-end hybrid.

Another aspect of the original specification was the controlled differential impedance of the bare flexible circuits. As usual practice in printed circuit board (PCB) production, the specification defined ± 10% tolerance by differential impedance control on dedicated test coupons during the flex PCB production. However, due to the very fine, 45µm line width and 45µm spacing of the tracks in these circuits and the 18 µm thick dielectric, it turned-out that the tight control of the differential impedance is very difficult and the impedance test coupons might not even represent the real circuit impedance correctly. Some full production lots with hundreds of circuits were about to be rejected and scrapped due to this criteria.

A careful analysis was carried-out in both cases and the specification was redefined to provide more margin for the production, while meeting the requirements for correct operation of the electronics and reliable wire-bonding during the module assembly.

The presentation will show the importance of a correct technical specification in a large size project through the impedance and wire bond pad cleanliness specification examples. It will emphasize the importance of representing the real requirements of a project to prevent unnecessary yield losses and price increase. It will present the methodology used to find these specifications and test the results proving that these new specifications are sufficient and correct.

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