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Production of flex circuits for the ATLAS ITk Pixel Outer Barrel

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The ATLAS ITk Pixel system requires large-scale flex circuits for low-voltage power, high-voltage sensor bias, and command/data transmission due to tight space constraints. This reports will focus on the design and production of the services that runs from the modules and the first patch panel of the ITk Pixel Outer Barrel. The results from the quality control tests on the pre-production (10% of what is needed to equip the final detector) will be discussed. In this report we also describe the procedure developed for the complex 3D bending needed to accommodate the routing and to respect the mechanical envelope.

Summary (500 words)

In the ATLAS ITk Pixel detector, the type-0 services are all the electrical links from the modules for powering, data, clock/command and DCS signals and the first patch panel (PP0). They are located on the detector itself, physically attached to the outer barrel structures. This report focuses on the design, production and quality control of the type-0 services for the ATLAS ITk Pixel Outer Barrel sub-system.

The PP0 (cf. Figure 1) connects the services that runs out of the detector volume on one side and links the modules on the other side. The PP0 is made of a PCB to route and distribute all the signals up to individual flexible wings. There are two versions for the flat part described in this document: the short one called M6 and the long one called M12, serving 6 and 12 modules, respectively. Each PP0 is equipped with a MOPS (Monitoring of Pixel System) chip.

The pigtail is the link between the PP0 wing and the module (cf. Figure 2). Several flavors are needed to be adapted to different regions of the detector. It is based on a multiflex PCB technology and it requires a complex 3D bending to accommodate the routing while respecting the mechanical envelope. Special molds had to be designed and experience showed that the pigtails inside the mold had to be warmed up to 100°C in order to fix the shape.

In this report we describe the tests and the results applied on PP0 and the pigtails. All the tests were done first in a flattened configuration, then after bending.

Dielectric withstanding voltage tests were performed and we measured leakage current below 10nA at 850V and 1125V. The dielectric breakdown voltage, a destructive test to identify the maximum voltage that the circuit can hold before failure occurs, showed values around 1650V.

To keep the power dissipation under control the maximum value for the resistance of the low-voltage circuit of the M12 and M6 PP0 plus their pigtails is fixed at 400mΩ. We measured a value of 269mΩ, so well within the limit. The breakdown of this measurement will be showed in the full report.

The temperature increase at 8A was also measured and found to be below the target value to keep the MOPS below 40°C.

As far as the data transmission is concerned, the main S-parameters, the impedance and the transmission quality of the pigtails and the PP0+pigtails system were measured. An attenuation of less than 5dB was found at 640MHz for the whole system. The cross-talk was found to be negligible (less than 50dB).

The bending procedure did not introduce any noticeable effect.

The result of the tests herein reported are for prototypes. The tests on the pre-production are currently on going and will be available for the conference.

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