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Radiation hard TwinAx for ATLAS ITk pixel electrical data transmission

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The high radiation dose and the cold environment at the HL-LHC pixel detector regions presents serious challenges for the survival of optical components. Radiation hard twinax cables are developed for the ATLAS ITk pixel data transmission within the pixel detector volume for up to 6m before transitioning to optical links at larger radius where radiation dose is reduced to acceptable level for optical components. We will present the design, qualification and industrialization process of the ATLAS ITk pixel electrical links using such twinax cables.

Summary (500 words)

The need for radiation hard electrical links operating in the cold volume of the ATLAS upgrade tracker led to the original custom TwinAx R&D in 2008. Most commercial twinax cables use PTFE as dielectric medium, but it is unfortunately radiation soft. The systematic evaluation of the transmission loss and radiation hardness of components led to the key conclusion that Low Density Polyethylene (LDPE) is the optimal choice of dielectric medium, balancing data transmission quality and radiation hardness. The original TwinAx prototype from Temp-Flex (now a subsidiary of Molex) from 2009 with AWG30 Cu-clad Al signal wires and LDPE dielectric achieved 6.2Gb/s over 6m once applied pre-emphasis and 8b/10b DC-balance. With the RD53 pixel readout chip for HL-LHC settled to1.28 Gb/s data links, a more compact version of the TwinAx with AWG34 Cu signal wires became the nominal baseline for both the command links and data links in the ATLAS ITk pixel system. Although the command links are operating at only 160 Mb/s, it also carries the clock to be recovered by the front-end chip so that it also requires Gb/s transmission quality.

In this presentation, we will describe the ATLAS ITk pixel TwinAx design philosophy with a drain wire to reduce shield material and manage termination heating. The thin jack further ensures the dimensions are minimized so that the high multiplicity of links can still fit into the very constrained service volumes. The design insertion loss is up to ˜14 dB @ 640 MHz after irradiation for a maximum length of 6m. The S-parameter measurements before and after irradiation, as well as performance and mechanical integrity checks at low temperature will be presented. To comply with CERN/EU fire retardancy requirements, a series of fire propagation, smoke and acidity certification tests are also performed. We will also present Signal Integrity test (Eye-Scans and Jitter analysis) for the E-link bundles, as well as integrated data transmission chain tests from pixel module to backend DAQ. Finally we will discuss the strain relief techniques to insure cable connectivity.

The ITk pixel TwinAx are organized into various types of E-link bundles depending on the detector region. The outer end of the bundles connecting to Optoboards are terminated with a rigid-flex for up to 8 command + 24 data links per Optoboard. The inner ends are terminated to the on detector Patch Panel 0 (PP0) with Samtec FireFly connectors with up to 12 links for the ˜17000 E-links of the Outer pixel subsystems, or directly soldered to a densely packed PP0 with up to 100 TwinAxes per PP0 for the ˜9200 E-links in the Inner pixel system. We will present the termination PCB designs, TwinAx ribbonization and bundle termination process bundle electrical test results. We will also describe the Inner system PP0 design and bundle packing tests.

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