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# Detector noise susceptibility issues for the future generation of High Energy Physics Experiments

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The electromagnetic noise characterization of the FEE and the compatibility of the different systems are important topics to consider during the experiment upgrades. A new power distribution scheme based on switching power converters is under study and will define a noticeable noise source very close to the FEE detector electronics. The knowledge of the FEE noise issues in previous detectors is an important object to guarantee the design goals and the good functionality of the detector upgrade. This paper shows an overview of the noise susceptibility studies performed in different CMS sub-detectors. The impact of different topologies in the final FEE sensitivity and design recommendations are presented to increase the robustness of the systems to the future challenging power distribution topologies.

## Summary

Electromagnetic noise and interference have been a major concern during the integration of the CMS experiments. Grounding and shielding problems have arisen during the integration stage in different sub-detectors requiring time, an important number of tests and studies to solve them. The effort to find the root cause and the solution of these problems can be minimized performing noise susceptibility studies during the design and the prototype stage of the FEE.

In general, most of the detector electromagnetic compatibility problems are associated with the noise level both generated by power units and radiated by the distribution system and the susceptibility of the FEE. Switching power supplies generate high frequency noise due to the switching action. This noise propagates through the distribution cables and boards, where can be either radiated to other systems or conducted to the FEE, reducing the performance of the experiment. Although a big effort is put in the converter design to reduce the noise emission, the levels achieved have to be directly compatible with the levels required by HEP detectors defined by the intrinsic FEE topology and the integration of the unit at system level. The front-end electronic noise sensitivity level can be either evaluated at the early stage of the system design via modelling and simulation or measured on prototypes. In the first case, corrective actions can be taken during the design stage, whereas in the second case, it is possible to identify from prototypes critical elements and inappropriate layouts that are responsible for the performance degradation of the FEE. To define the immunity level of the FEE to conductive disturbances, several tests are conducted by injecting currents through the FEE input power terminals and slow control cables. The goal of these tests is two-fold: firstly, the test will characterize the immunity of the system to RF perturbations defining weak points in the design and second, it will provide data to define the emission level to be imposed to the switching power supply connected to them.

This paper presents the characterization of the FEE sensitivity of different CMS subsystems to common mode and differential noise. The variation of the susceptibility function corresponding to different CMS front-end electronics respect to the grounding connection, filter implementation, cable and shield connections, detector-FEE connections and PCB designs are analyzed. Noise immunity tests and numerical simulations of the FEE susceptibility have been used to evaluate the weakest areas of the system and to define the impact of the design in the noise immunity of the next generation of high energy physics experiments. Based on these measurements and analysis, design recommendations are presented to increase the robustness of the system to the future challenging power distribution topologies.

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