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Electromagnetic Compatibility of a DC Power Distribution System for the ATLAS Liquid Argon Calorimeter

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The front end electronics of the ATLAS Liquid Argon Calorimeter is powered by DC/DC converters nearby the front-end crates. They are fed by AC/DC converters located in a remote control room through long power cables. The stability of the power distribution scheme is compromised by the impedance of the long interconnection cable, and proper matching of the converters dynamic impedances is required. Also, the long power cable fed by a powerful AC/DC converter is a source of electromagnetic interferences in the experimental area. The optimal grounding and shielding configuration to minimize these EMI is discussed.

Summary

I. POWER DISTRIBUTION SCHEME FOR THE LIQUID ARGON DETECTOR
The amount of power required by the front end crates of the Liquid Argon Detector of the ATLAS experiment imposes the presence of a power supply in their vicinity. As the magnetic field limits the use of power transformers, a front end power supply based on modern DC/DC converters was chosen. AC/DC converters that sit in a control room located 100 meter away of the detector provide the bulk power to the front end power supplies.
The long DC power link faces several electromagnetic compatibility issues that are specific to this configuration:
• Stability of the power link.
• Common mode and differential mode noise propagation along the cable.
• EMI emissions of the power cable.

II. STABILITY OF THE DC POWER LINK
When both AC/DC and DC/DC converters chained together, the resulting transfer function involves the ratio between the output impedance of the AC/DC converter and the input impedance of the DC/DC converter. The stability of the system must be insured by proper matching of the converters impedances.
The impedance of the long cable used to link the converters is the dominant factor in the transfer function. The resulting impedance seen by the DC/DC converters towards the back end power supply is considerable, and the gain and phase margins become critical for the overall stability.

III. NOISE PROPAGATION ALONG THE LINK
The long DC power link is modelled as a multiconductor transmission line. As the impedances at both ends of the cable are low, the CM current gets amplified at some resonance frequencies as it propagates along the cable. The resonance frequencies must be known to make sure they do not match an eventual resonance of the front end DC/DC converter input filter.

IV. EMI EMISSIONS OF THE DC POWER LINK.
The power converters are a source of CM and DM noise. The noise source is identified as inductive in the near field region.
The DM noise is caused by the back end converter filtering, and by the front end switching device. It is a source of electromagnetic interferences at low frequencies.
The common mode noise is contributed by the switching devices of both converters. As it returns through the ground, it is a potential source of strong EMI emission.
The CM noise is the dominant source of EMI by several orders of magnitude when compared to the DM source.
In sake of a healthy electromagnetic environment of the experiment, the EMI

emissions caused by CM and DM noise must be minimised. This is achieved by shielding the link; the shield is preferably grounded on both ends to provide and adequate return path for the CM currents in a minimised loop.

V. CONCLUSION
The DC power link used to feed the front end electronics of the Liquid Argon Calorimeter brings specific electromagnetic compatibility issues. The critical stability requirements are analysed and measured. The noise propagation along the line is measured to identify the resonance frequencies of the power link. The converters input and output filter must be such that they do not resonate at the link critical frequencies. The optimal shielding method that minimises the EMI emissions of this setup is last achieved by connecting the shield on both ends.

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