Liquid level monitoring with a differential capacitive sensor for the LUX-ZEPLIN dark matter experiment

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One of the experimental techniques used for the direct detection of dark matter with noble liquids is the two-phase liquid/gas time projection chamber (TPC). Experiments such as LUX-ZEPLIN (LZ) exploit such technology in the attempt to detect the presence of dark matter through the discrimination between nuclear and electron recoils. In order to achieve optimal discrimination, understanding the liquid/gas interface has become increasingly important for large experiments. Precision level sensors can be installed around the upper part of the TPC to aid this understanding. These sensors must be intrinsically radio-pure and able to operate in regions of high electric fields. In order to achieve the required suppression for external sources of background radiation, the LZ TPC is installed within a range of outer detectors. This configuration requires the use of long cables between the sensors and the readout electronics which can introduce a significant systematic error in the level measurement due to cable capacitance. Potential variation in this cable capacitance due to temperature changes as the cable moves from liquid xenon temperature to room temperature negates the use of a simple correction factor.

In this talk, we report the novel differential capacitive sensor design used to maximise the sensitivity to small changes in liquid level (measured at the 10^{-12} farad level with 10^{-15} farad precision) whilst mitigating the systematic error associated with the cable capacitance (at the 10^{-9} farad level). We also report on the studies conducted and the tests performed to confirm that the sensors can be operated in high E-field regions. Finally, we report on how the cleanliness and radiopurity requirements for LZ impact the design and material selection for these sensors.