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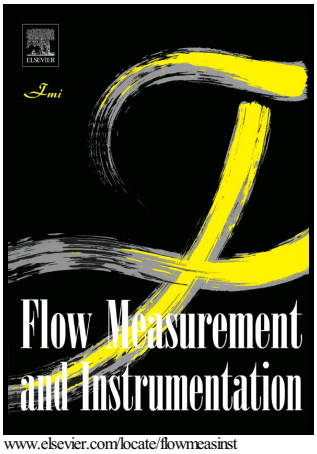

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A Novel Multi-electrode Sensing Strategy for Electrical Capacitance Tomography with Ultra-low Dynamic Range

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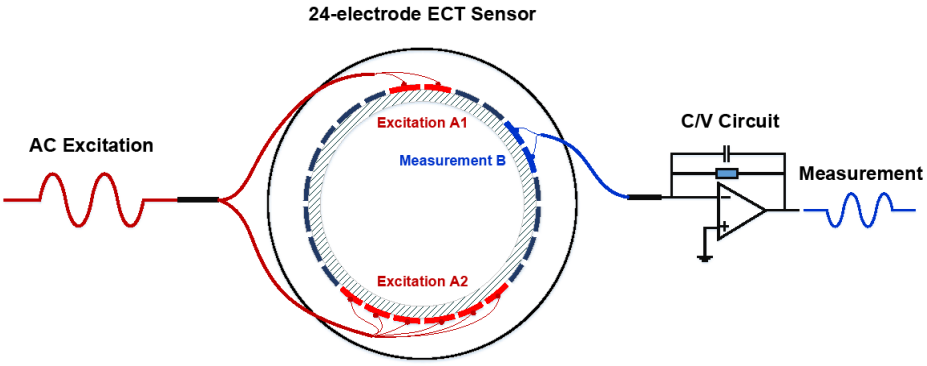
Abstract

Common sensing strategy of Electrical Capacitance Tomography (ECT) is to measure the capacitances across all independent combinations of individual electrodes. The capacitance values from conventional sensing strategies usually have large dynamic ranges and severe nonlinear effect in reconstructed images when using linearized ECT model, thus making it difficult to obtain satisfactory images. In this paper, a novel multi-electrode sensing strategy for ECT with ultra-low dynamic range is reported to offer improved solutions regarding these problems. The proposed sensing strategy takes advantage of the flexibility of combining electrode method, while a new opposite multi-electrode simultaneous asymmetric excitation and measurement protocol is further developed. A 24-electrode ECT sensor is selected as the basic sensor, and a pair of asymmetrically opposite electrodes are excited in a simultaneous manner. The proposed sensing strategy can significantly decrease the dynamic range of measurements compared with our former reported work. Moreover, nonlinear effect is weaker compared with that of conventional sensing strategy when performing linearized-model-based image reconstruction. To validate the proposed sensing strategy, modelling of 3D ECT sensors and numerical analysis are carried out. The proposed strategy is characterized from the aspects of capacitance measurement, compression ratio, dynamic range, sensitivity map, and quality of reconstructions. Additionally, preliminary experimental validation is also conducted. Both simulation and experiment results indicate significantly improved sensing characteristics and quality of reconstructed images. The novel sensing strategy will lead to a lower burden for capacitance measurement circuit and better quality of tomographic image.



Keywords: Electrical Capacitance Tomography; multi-electrode sensing; simutaneous asymetric excitation; image reconstruction

1. Introduction

Electrical Capacitance Tomography (ECT) is one of the industrial process tomography modalities. Its working principle is to measure capacitances between sensor electrode pairs and estimate the permittivity distribution inside pipelines or vessels via a visualized manner [1]. Attributing to its advantages of non-invasiveness, non-radiation, high temporal resolution, economy and usability, ECT has been widely studied and applied to reveal process characteristics. Numerous successful cases have been reported, including fluidized bed monitoring [2], gas/oil/water multi-phase flow measurement [3], flow velocity measurement [4], and flame imaging [5], etc. In spite of its