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SCHOOL OF MECHATRONIC SYSTEMS ENGINEERING

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Characterization of Strongly Coupled Micro-Resonator Systems for Multi-Sensor Applications

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Abstract

The objective of this research is analyzing the behavior of strongly coupled micro-resonating systems. In coupled resonator arrays, the additional degrees of freedom from coupling of the resonators to each other can be employed to enhance the sensitivity and selectivity of the sensor system. In order to achieve this, the effect of coupling strength on sensitivity of the system is investigated. It is shown that sensitivity of the sensor system to perturbations can be increased significantly through proper selection of the coupling coefficient between resonators. It is further shown that by increasing the strength of the coupling between resonators, eigenfrequencies are more sensitive to the external perturbations compared to eigenmodes. It is established that by moving to the strongly coupled region, the sensitivity of the coupled system to the input is increased compared to uncoupled resonator systems.

A method for processing signals from a coupled resonator array is developed to detect perturbations due to the external stimuli. A formula is developed which relates the perturbation ratio to the relative change in eigenvalues before and after insertion of perturbation. The method is based on analyzing the relative differences between eigenvalues of the system, which is in contrast to the commonplace methods of focusing on individual modes of a the coupled system. Besides enhanced sensitivity, this property can be employed to reduce the effect of manufacturing tolerances on the sensor system response through proper design of the coupling elements. The proposed model is experimentally verified using coupled resonator arrays fabricated through in-house and standard micro-fabrication processes.

Keywords: Coupled Resonator Array; Strongly coupled system; Resonance; Perturbation; eigenvalues; eigenmodes.