MAGNETIC-FREE RF CIRCULATORS USING MEMS RESONATORS

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This paper presents design and analysis of a magnetic-free RF-MEMS non-reciprocal device based on the capacitive modulation of three identical Lithium Niobate (LN) lamb wave resonators [1] using the varactor diodes, demonstrating a giant non-reciprocity (60 dB) at 840 MHz with an insertion loss (IL) of -13 dB, bandwidth (BW) of 4 MHz, and frequency tunability of 5%.

Circulator is a passive, non-reciprocal 3-port device which transmits RF signal entering any port to the next port only in one direction. These devices play a crucial role in communication systems; *i)* protecting source generators from the reflected signals as an isolator and *ii)* enabling transmitter and receiver to share the same antenna for the full-duplex wireless. Most common approach for breaking the reciprocity is to use an external magnetic field in a ferromagnetic media [2]. However, this approach not only requires bulky magnets increasing the size/weight and but also has limited integration with CMOS process/devices. Alternative approaches have been developed in [3, 4] where three identical coupled LC resonators are modulated via spatiotemporal modulation using ring or wye topology. These approaches provide a strong non-reciprocity in the range of 40-50 dB and reasonable IL and BW; however they are limited with the necessity of the use of filters or diplexers as a part of the biasing network, complexing the design. Another approach, CMOS circulators, is based on the implementation of N-path filters using high speed-transistors as a switch [5]. However, this approach is not amenable to mm-wave due to the stringent clocking requirements and transistor parasitics. Very recently, a 28 GHz CMOS circulator based on the spatio-temporal conductance modulation has been demonstrated in [6] with a limited non-reciprocity.

In this work, we demonstrate circuit-level analysis and practical considerations for the design of magnetic-free MEMS circulators using wye-connected MEMS resonators with varactor diodes. ADS simulations show that a MEMS resonator with a low R_x and C_0 will provide the development of a MEMS based circulator with a giant non-reciprocity, low IL and high BW.

References

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