ABSTRACT

Novel RF MEMS tunable filters with adjustable spurious suppression

(December 2008)

Vikram Sekar

Chair of Advisory Committee: Kamran Entesari

This thesis presents the theory and design of fixed and Radio Frequency (RF) Microelectromechanical Systems (MEMS) -based tunable microwave filters for RF and microwave applications. The methodology for the design of coupled resonator filters is explained in detail and is used to design an end-coupled microstrip filter at 1.5 GHz with inductive loading using a stepped microstrip discontinuity to lower the resonance frequency of the half-wavelength microstrip resonator. The fabricated endcoupled filter shows center frequencies of 1.36 GHz and 1.03 GHz in the unloaded and loaded state respectively, with insertion losses between 1.2-1.5 dB and return loss better than 10 dB in both states. The filter response shows spurious passbands at approximately twice the filter center frequencies. To overcome this problem and improve the upper rejection skirt of the filter, microstrip resonators with tapped input/output coupling and mixed inter-resonator coupling are used to suppress the spurious passband by introducing a transmission zero at spurious resonance frequency. Measurement results for the fabricated tapped-resonator filters show an improvement of the upper rejection skirt due to spurious suppression to a level of -40 dB, with insertion loss of 1.2-1.5 dB for the same center frequencies. The concepts developed from fabrication and measurement of fixed-tuned microstrip filters are used to design an inductively-loaded RF MEMS tunable filter with adjustable spurious suppression implemented using packaged metal-contact switches. The two-pole 5% filter has a tuning range of 17% from 1.06 GHz to 1.23 GHz with an insertion loss of 1.56-2.28 dB and return loss better than 13 dB over the tuning range. The inductive loading mechanism is used to tune the open-ended quarter wavelength stub such that a tunable transmission zero supresses the spurious resonance as the filter center frequency is tuned. The spurious passband response in both states is suppressed below -20 dB. The unloaded quality factor (Q) of the filter varies from 127 to 75 as the filter is tuned. The equivalent circuit model for the series metalcontact packaged RF MEMS switch used in the tunable filter is derived from full-wave electromagnetic simulations and used to predict the effect of MEMS switch parasitics on the overall performance of the tunable filter.