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High frequency tuning mechanism using nanoplasma

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ABSTRACT

The ever growing demand for reconfigurable electronic devices at mobile form factors makes RF tunable devices and circuits increasingly important. Conventional tuning mechanisms typically rely on controlling material properties or dimensions. These are often achieved by using electrical, mechanical, or thermal approach. On the other hand, the tuning principle of this study is based on changing the electron number density and consequently the permittivity and conductivity of a plasma region which are functions of the applied electric field strength. Consequently, it is possible to form a controllable RF medium by just changing the applied DC voltage without involving mechanical motion as is the case in tunable MEMS devices. As an illustrative example, a dual-capacitively-loaded cavity resonator is considered in this study. Tunable RF filters are critical parts in modern wireless communication systems for selecting the desired frequency bands. Because of the limited bandwidth, widely tunable filters with narrow instantaneous bandwidths and high quality factors (Q) are in high demand these days. Such filters have been successfully implemented by using high-Q resonators. Capacitively-loaded or evanescent-mode (EVA) cavity resonators have been used widely for this end, which have much smaller size and the ability to tune with a moderate reduction of their Q. An EVA resonator is formed by placing a loading post in the center of a simple cavity. In this way, most of the electric field is concentrated in the gap between the post-top surface and the top wall which actually forms the quasi-static capacitance of the resonator. Instead of changing the gap size by displacing the top wall that is often accomplished by MEMS tuners, the resonant frequency can also be tuned over a large frequency range by creating a nano-plasma layer. In this study, the initial static resonator is designed to have two resonant frequencies to continuously cover a wide range. It is shown that for a sample designed resonator with initial resonant frequencies of 39 GHz and 55 GHz, the frequency tuning range will be from 27.2 GHz to 55 GHz which means more than one octave of tuning. Another advantage of this technique is that it is possible to have either dual frequency operation or a single band by appropriately selecting the two initial resonances.