Feasibility Study on the Microfabrication of MEMS Integrated Antenna

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Principal Investigators: Bedri Cetiner, Qingzhou Xu
Users: Bedri Cetiner, Qingzhou Xu

Affiliation: Space Science Center, Morehead State University
Primary Funding: NSF EpsCore and Kentucky Rural Innovation Fund
Contact: ba.cetiner@morehead-st.edu, q.xu@morehead-st.edu

Abstract

An annular slot antenna has been constructed on microwave laminate. Two radio frequency microelectromechanical system (RF MEMS) switches are placed across the outer slot to connect/disconnect the ground and the inner strip. One switch is placed along the feeding microstrip line on the back side of the antenna and it allows the selectivity to feed either slot. When no switches are activated, the outer slot is fed to radiate at 2.4 gigahertz (GHz); when all the three switches are activated, the inner one is fed to radiate at 5.3 GHz. The frequency selection is realized by controlling the on/off states of the RF MEMS switches.

Summary of Research

Next-generation wireless communications in both commercial and military applications are increasingly moving to small, light-weight, and high-frequency systems with increased functionality and reduced power consumption. A concurrent trend in communication is to develop multi-mode/band systems on a single platform. These communication systems are becoming ever more complex with dozens of standards, a mixture of analog and digital formats and a diversity of spectral utilization. In many cases, these communication systems need to be supported by a number of antennas, which often radiate different frequency bands, polarizations and radiation patterns.

For a multi-mode/band system on a single platform, if one antenna is devoted to each mode/band operation, the limited space quickly becomes littered with antennas, and the use of dedicated antennas is costly, leads to unwanted proximity-coupling and degrades the overall performance. One solution, which keeps the entire system compact and satisfies multi-mode/band operations, is to design a single antenna that can be reconfigured or tuned to deliver the desired frequency bands, polarizations and radiation patterns without sacrificing radiation efficiency.

The radiation behavior of an antenna depends on the distribution (path and electrical length) of the resonant currents over the antenna surface, which is further determined by antenna geometrical parameters, such as size, shape and position of radiating and parasitic elements. Reconfiguring these parameters enables multiple functions to be performed with the same antenna structure. A number of approaches have been proposed for implementing reconfigurable antennas [1-4]. Most of these approaches make use of switches or varactors to change the physical dimensions of an antenna structure or the distribution of the antenna resonant currents.

Reconfiguring antennas can be realized by using semiconductor devices (PINs and FETs) and RF MEMS switches. For semiconductor devices, when the signal frequency becomes greater than 1 GHz, they have large insertion losses and poor isolation. They produce...
significant intermodulation distortion as a consequence of their non-linear I-V feature. The antennas made by using these devices will be characteristic of high power consumption. RF MEMS switches are devices that use mechanical movement to achieve an on/off operation. They have very high isolation, very low insertion loss and very high linearity. The RF MEMS switches based on electrostatic actuation have near-zero power consumption. Being essentially broadband devices, RF MEMS switches are far less affected by frequency and are more suitable for high-frequency applications. Most importantly, the MEMS technology enables monolithic integration with antenna radiating elements. RF MEMS switches are now increasingly used to realize reconfigurable or tunable RF devices, components and systems. As RF MEMS switches are becoming mature, it is important to develop novel ideas and practical approaches to make full use of MEMS switches’ remarkable characteristics and to achieve novel, high-performance RF devices, components and systems.

In the previous year, we worked on a reconfigurable annular slot antenna. The antenna is designed to primarily realize frequency band selectivity while maintaining radiation pattern. Slot antennas are attractive for many communication and radar applications due to geometric simplicity, efficiency, reliability, and light-weight. It is known that an antenna alters its radiation characteristics when its physical geometry is changed. The change here is realized by RF MEMS switches that are located at the annular slots and along the signal-feeding microstrip line. Figure 1 shows the front side of the annular slot antenna constructed on a TMM10i ($\varepsilon_r = 9.8$, $\tan\delta = 0.002$) Rogers microwave laminate. Two switches are placed across the outer slot to connect/disconnect the main ground and the inner metal stripe. Figure 2 shows the double-arm DC contact RF MEMS switch used in this implementation. The dual band behavior is achieved by selectively activating the two concentric radiating slots. One RF MEMS switch is placed along the feeding microstrip line on the back side of the antenna and it allows the selectivity to feed either slot.

When no switches are activated, the outer slot is fed to radiate at a low frequency of 2.4 GHz; when all the three switches are activated, the inner one is fed to radiate at a high frequency of 5.3 GHz. Figures 3 shows the simulated and measured return losses corresponding to the two operation modes, respectively. As shown, the frequency selection is realized by controlling the on/off states of the RF MEMS switches. The measured frequency locations are in good agreement with the simulated results with a very small discrepancy at 5.3 GHz.

**References**


