

Fully Reconfigurable Highly Selective RF Filters and Duplexers for Multifunctional and Multistandard RF Front Ends

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Abstract—This report describes the results of the research that was supported in part by the 2018 MTT-S Graduate Fellowship Award. This research project included the design and implementation of highly selective and fully reconfigurable RF filters and duplexers for next generation transceivers. The designs focused on obtaining high selectivity through the inclusion of multiple transmission zeros, low loss and high linearity through tuning only the resonant frequencies of the resonators within the filters and duplexers (as opposed to tuning the couplings), and wide tuning ranges in terms of center frequency and bandwidth. The devices in this project outperformed the state-of-the-art in terms of tuning ranges and insertion loss.

Index Terms—Balanced filter, bandpass filter (BPF), differential filter, duplexer, microstrip filter, multi-band filter, reconfigurable filter, tunable filter.

I. INTRODUCTION

NEXT-generation RF transceivers will require reconfigurable RF front ends that can support a variety of standards and waveforms while operating under a dynamic RF environment that contains multiple sources of interference [1]. Due to their ability to protect these systems against unwanted interference and noise, pre-select bandpass filters (BPFs) and duplexers are key components in the receiver chain. As is well-known, low loss, miniaturized size, wide tuning ranges, and high selectivity are important requirements for these devices to ensure robust and efficient acquisition of desired signals.

This research, which was funded in part by the 2018 MTT-S Graduate Fellowship Award, focused on the design and implementation of highly selective and fully reconfigurable (i.e., tunable in bandwidth and center frequency and can be intrinsically switched off) RF filters and duplexers. The work supported by this fellowship has led to a total of four accepted conference papers [2]-[5] and one that is currently under review. Specifically, the research included a highly selective static duplexer [2], a static differential dual-band filter [3], a widely tunable tri-band filter [4], and two tunable fifth-order filters and a tunable duplexer in [5]. As opposed to conventional tuning schemes in which both couplings and resonators are tuned, the filters in this work are only tuned by varying the

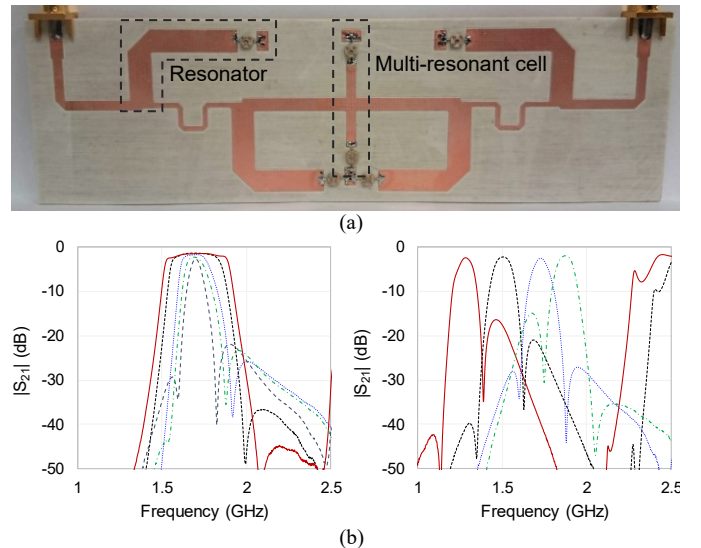


Fig. 1. Fully reconfigurable fifth-order BPF. (a) Photograph of the BPF that outlines an open-ended capacitively loaded half-wavelength long resonator and a multi-resonant cell that consists of two open-ended capacitively loaded quarter-wavelength long resonators. (b) Measured bandwidth and center frequency tuning.

resonant frequencies of their constituent resonators, which leads to lower levels of insertion loss and higher linearity.

The rest of this report is organized as follows. Section II reports some of the results of the work presented in [5]. Specifically, one of the reconfigurable fifth-order BPFs and the reconfigurable duplexer are reported on. In Section III, the impact of this fellowship and my future career plans are expounded. Lastly, a brief conclusion is given in Section IV.

II. PROJECT RESULTS

Fig. 1 shows the results of the one of the two fully reconfigurable fifth-order BPFs presented in [5]. Specifically, Fig. 1(a) shows a photograph of the microstrip prototype and Fig. 1(b) demonstrates the measured tuning results. As can be seen, the filter is composed of four open-ended half-wavelength resonators, which introduce one pole each to the response, and one multi-resonant cell, which introduces two transmission

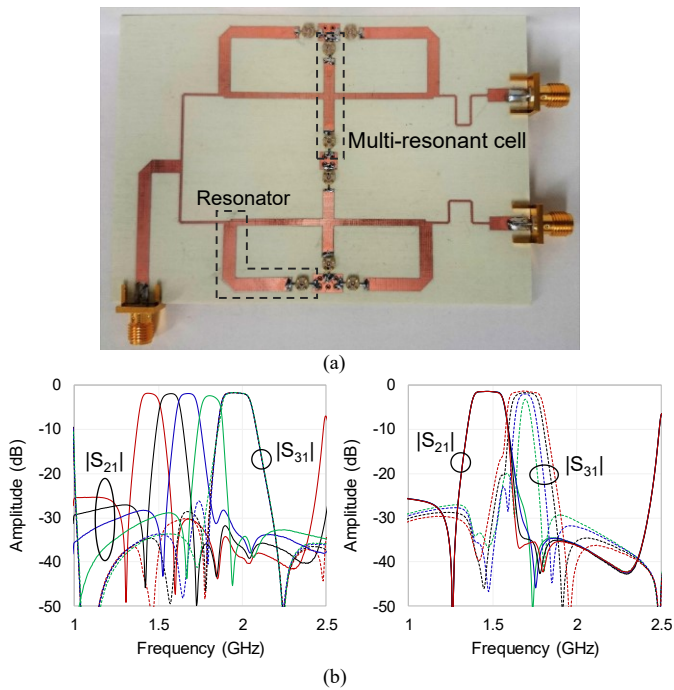


Fig. 1. Fully reconfigurable duplexer with third-order channels. (a) Photograph of the duplexer that outlines an open-ended capacitively loaded half-wavelength long resonator and a multi-resonant cell that consists of two open-ended capacitively loaded quarter-wavelength long resonators. (b) Measured bandwidth and center frequency tuning.

zeros and one pole. The multi-resonant cell comprises two open-ended quarter-wavelength long resonators. To achieve tunability each of the resonators is capacitively loaded with mechanically tunable capacitors from Johanson Manufacturing. The filter can be tuned in frequency from 1.28 to 1.88 GHz (i.e., 1.5:1 tuning ratio) and in bandwidth from 72-387 MHz (i.e., 5.4:1 tuning ratio). The filter exhibited the largest bandwidth tuning range and among the widest tuning ranges when compared to high-order filters (order >3) in the open technical literature. As an added feature, the BPF can also be intrinsically switched off to give an all-reject mode, although it is not shown here.

Fig. 2 shows the fully reconfigurable duplexer that is presented in [5]. Using a similar topology to the BPF in Fig. 1, the duplexer contains two channels, each made up of a reconfigurable third-order filter. Each filter consists of two open-ended half-wavelength long resonators and one multi-resonant cell. Tuning was achieved in a similar fashion to the filter in Fig. 1. Both channels of the duplexer are fully reconfigurable independent of each other. They exhibit frequency tuning of about 1.3:1 and bandwidth tuning of about 4.5:1.

III. FELLOWSHIP IMPACT AND CAREER PLANS

First and foremost, I would like to thank the IEEE MTT-S for granting me the 2018 MTT-S Graduate Fellowship Award. This award has supported my work that has led to multiple conference papers [2]-[5]. Additionally, the travel grant from the award allowed me to attend IMS 2018 in Philadelphia, PA. It was the first large-scale conference that I have attended and it was an eye-opening experience. I presented two works at the conference and engaged with many experts in my field. The diversity of great research being done in microwave engineering that I was exposed to at IMS 2018 excited me to continue my own research.

In the short term, I am going to continue my research in reconfigurable RF filters and duplexers as well as expand the breadth of my research into other exciting projects such as antennas and antenna feed-networks. My long-term goals include finishing my PhD program within the next 2-3 years and continuing working in the field of microwave engineering. I plan on working in both industry and academia in the future because both domains present different experiences that will allow me to further learn about my field. I intend to continue living in Colorado upon graduation.

IV. CONCLUSION

A brief summary of the research that was supported in part by the 2018 MTT-S Graduate Fellowship Award has been presented. The projects include various topologies of highly selective and fully reconfigurable RF filters for next generation multifunctional RF front ends. All of the work supported by the fellowship [2]-[5] has been or will be presented at different microwave conferences.

REFERENCES

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