Selectivity-tuned bandpass filter

Z. Brito-Brito, I. Llamas-Garro and L. Pradell

A bandpass filter able to electrically fine tune selectivity is presented. The reconfigurable filter topology has four poles and a quasi-elliptic bandpass filter response. The device is tuned by *pin* diodes which select tiny stubs that reconfigure filter selectivity without degrading filter return loss throughout the passband. Simulations and measurements are in good agreement.

Introduction: Filters having transmission zeros at finite frequencies have improved selectivity compared to Chebyshev filters, and can be used to separate narrow adjacent channels in communication systems. It is well known that temperature variations of microwave substrates [1, 2], or fabrication tolerances [3], can slightly mistune a filter out of an optimum response. Fine tuning techniques can adjust a filter response to overcome temperature variations or fabrication tolerances. Previous work involving reconfigurable transmission zeros, focuses on changing the position of a single transmission zero from one side of the passband to the other [4–6]. In this Letter we focus on selectivity fine tuning where a pair of transmission zeros are moved closer or farther to the filter centre frequency. Four selectivity states are obtained using two switchable tiny stubs, which modify the coupling between a pair of resonators.

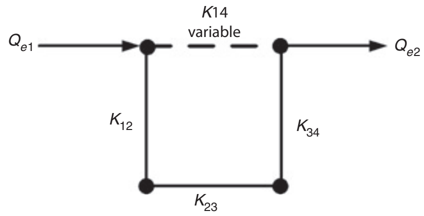

Fig. 1 *Filter general coupling diagram*

Table 1: Fixed coupling coefficients

$K_{12} = K_{34}$	0.0581
K_{23}	0.0543
$Q_{e1} = Q_{e2}$	9.5356

Table 2: Variable coupling coefficient

State	K_{14}
1	0.0097
2	0.0123
3	0.0173
4	0.0198

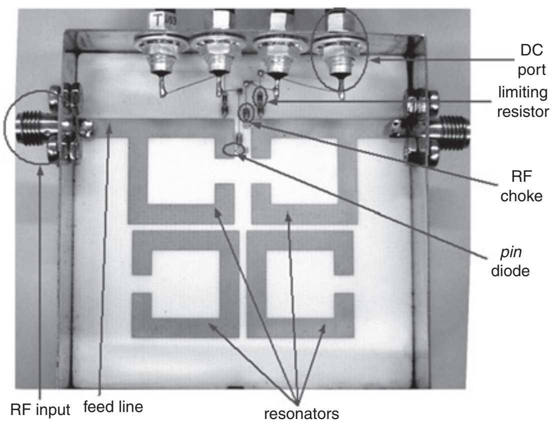

Fig. 2 *Photograph of fabricated filter*

Filter topology: The proposed selectivity reconfigurable device is based on the filter presented in [7], and consists of a four-pole quasi-elliptic bandpass filter using microstrip open-loop resonators. The filter is composed by four inter-resonator couplings K_{12}, K_{23}, K_{34}, K_{14}, and input/output couplings to the circuit Q_{e1} and Q_{e2} as shown in Fig. 1. In this filter topology, coupling K_{14} in Fig. 1 is variable, and can take four different values resulting in a reconfigurable selectivity. The filter was designed to have a 10% fractional bandwidth with a 1.7 GHz centre frequency. The theoretical fixed couplings for the device are shown in Table 1, and the theoretical values of the reconfigurable coupling K_{14} are shown in Table 2, where filter selectivity increases as K_{14} increases. The fabricated filter is shown in Fig. 2, and consists of four open-loop resonators with a tapped input and output coupling to resonators 1 and 4. The variable electric coupling K_{14} is tuned using two tiny stubs of different length connected by *pin* diodes. The proposed filter is able to switch between four different selectivity states discretely, defined by selecting a combination of *pin* diodes in the off or on state. The coupling coefficients are found using the method described in [7] by carrying out full-wave electromagnetic simulations, including lumped element models for the *pin* diodes and choke inductors [8]. The filter was fabricated on a 1.524 mm-thick Rogers substrate having a 35 μm copper metallisation. The diodes were HPND-4028 Avago Technologies beam lead *pin* diodes. The bias network consisted of a choke inductor and a 1 kΩ resistor to limit the current on each diode to 10 mA in the forward bias state; a voltage of −10 V was supplied in the reverse bias state.

Results: Figs. 3 and 4 show the simulated [8] and measured response for the four discrete states, respectively. Measurements were taken using an HP 8510C network analyser. The comparison between simulated and measured results shows very good agreement in terms of selectivity tuning and passband return loss. Selectivity increased from the off-off state to the on-on state as expected. When both diodes are reverse-biased, none of the stubs are selected, producing the off-off state. When the left diode is reverse-biased and the right diode is forward-biased the shorter stub is selected, increasing the selectivity and producing the off-on state. The longer stub is selected by polarising the left diode in a forward-biased state while keeping the right one reverse-biased, defining the on-off state with a higher selectivity than the previous state. Finally, when both diodes are forward-biased the highest selectivity is achieved corresponding to the on-on state.

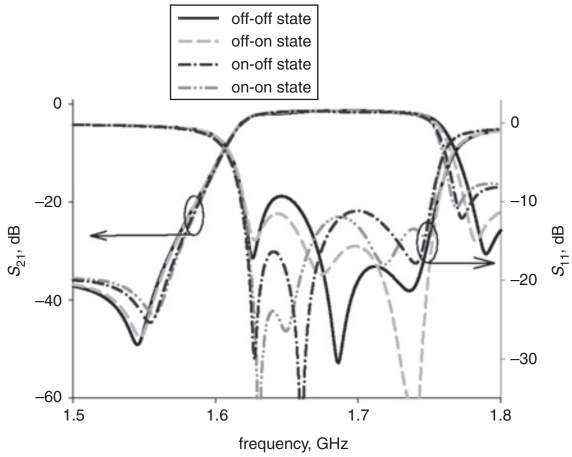

Fig. 3 *Simulated filter response*

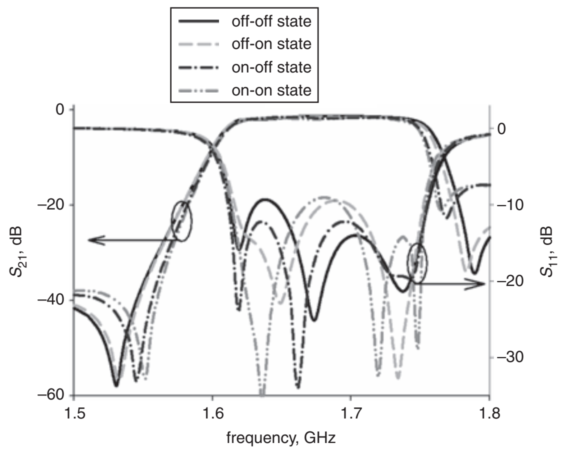

Fig. 4 *Measured filter response*

Conclusion: A reconfigurable bandpass filter providing selectivity fine tuning has been presented. Selectivity tuning has been obtained by selecting two tiny stubs placed between a pair of resonators. Two *pin* diodes have been used to select the stubs, resulting in four discrete states. Selectivity fine tuning can compensate substrate temperature variations or fabrication tolerances. Simulations and measurements are in very good agreement.

Acknowledgments: This work has been financed by research project TEC2007-65705/TCM from the Spanish Ministry of Education. Z. Brito-Brito thanks CONACYT, Mexico, for scholarship no. 207926/302540. The authors thank G. Navarro-Muñoz for assisting with simulations.

6 April 2009
doi: 10.1049/el.2009.0958

Z. Brito-Brito, I. Llamas-Garro and L. Pradell (*Signal Theory and Communications Department, Technical University of Catalonia, 08034 Barcelona, Spain*)

E-mail: llamasi@theiet.org

References

1 Traut, G.R.: 'Electrical performance of microwave boards'. 44th Electronic Components and Technology Conf. Proc., May 1994, pp. 557–563
2 Mazierska, J., Jacob, M.V., Ledenyov, D., and Krupk, J.: 'Loss tangent measurements of dielectric substrates from 15K to 300K with two resonators: investigation into accuracy issues'. Asia-Pacific Microwave Conf. Proc., Vol. 4, December 2005
3 Yan, W.D., and Mansour, R.R.: 'Micromachined millimeter-wave ridge waveguide filter with embedded MEMS tuning elements'. IEEE MTT-S Int. Microwave Symp. Dig., June 2006, pp. 1290–1293
4 Fathelbab, W.M., and Steer, M.B.: 'A reconfigurable bandpass filter for RF/microwave multifunctional systems', *IEEE Trans. Microw. Theory Tech.*, 2005, **53**, (3), Part 2, pp. 1111–1116
5 Zhang, H., and Chen, K.J.: 'A microstrip bandpass filter with an electronically reconfigurable transmission zero'. 36th European Microwave Conf. Proc., September 2006, pp. 653–656
6 Liao, C.-K., Chang, C.-Y., and Lin, J.: 'A reconfigurable filter based on doublet configuration'. IEEE MTT-S Int. Microwave Symp., June 2007, pp. 1607–1610
7 Hong, J.-S., and Lancaster, M.J.: 'Couplings of microstrip square open-loop resonators for cross-coupled planar microwave filters', *IEEE Trans. Microw. Theory Tech.*, 1996, **44**, (11), pp. 2099–2109
8 Agilent Advanced Design System, http://www.agilent.com