A 3rd order ridge waveguide filter with parallel coupled resonators.

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***Abstract* — A 3rd order novel compact E-plane ridge waveguide filter is presented. Miniaturization of 2:1 is achieved upon introducing a configuration of parallel coupled E-plane ridge waveguide resonators. The presented filter allows for a transmission zero at finite frequencies to address sharp cutoff specifications. Furthermore it maintains the fabrication simplicity and mass-producibility of standard E-plane filters. Numerical and experimental results are presented to validate the presented configuration.**

***Index Terms* — Ridge waveguide, filters, miniaturization, transmission zero**

I. INTRODUCTION

All-metal inserts mounted in the E-plane of a split block waveguide housing is a well-established technique for realising low-cost and mass producible microwave configurations, such as bandpass filters [1]. However, despite their favourable characteristics, E-plane filters suffer from bulky size [2, 3] and stopband performance that may often be too narrow for many applications, such as multiplexers. Furthermore, many multi-channel or diplexer applications require filters with sharp cutoff, in order to accommodate for closely spaced frequency channels and avoid cross-talk.

In order to address the problem of spurious passband of E-plane filters, earlier work proposed to integrate the standard bandpass E-plane filter with a periodic lowpass E-plane structure [4]. This configuration can suppress the spurious harmonic resonances of the bandpass filter. However, the disadvantage of this configuration is the increased physical dimensions. Furthermore, the requirement of steep attenuation slopes is very conveniently addressed with transmission zeros positioned close to the cutoff of the filter, rather than increasing the order of the filter, which in turn would increase the size and the losses.

This contribution proposes a novel configuration that reduces the physical dimension of bandpass E-plane filters to approximately half. A 3rd order design is presented as an example. The proposed filter is completely compatible with the low-cost and mass-producible fabrication process of all-metal insert E-plane filters [5] and can be directly integrated with lowpass (EBG) waveguide components for suppression of the spurious harmonic resonances [4].

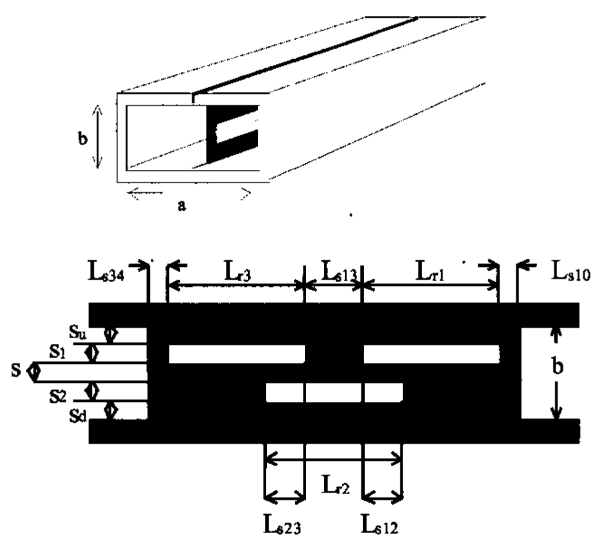

Fig. 1. Layout of proposed configuration (3rd order filter)

The improvement is achieved upon introducing parallel coupling between the resonators of ridge waveguide filters. Narrow gap resonators are coupled both in series and in parallel. This results in a significant reduction of the total size of the filter. Furthermore, the topology allows for cross-coupling between the resonators, thus introducing transmission zeros at finite frequencies. The performance of the proposed topology is demonstrated using a third order filter design. By means of simulated end experimental results it is demonstrated that the presented filter can achieve steep attenuation slopes.

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TABLE I

DESIGNED PROTOTYPE FILTER DIMENSIONS

$L_{s10} = L_{s34}$	0.50	$L_{r1} = L_{r3}$	15.00	s	2.40	a	22.86
$L_{s23} = L_{s12}$	5.50	L_{r2}	15.00	$s_1 = s_2$	2.00	b	10.16
L_{s13}	4.00			$s_u = s_d$	1.88	t	0.10

II. DESIGN

Full-wave transverse resonance technique has been implemented to solve electric field distribution in ridge waveguide with thin ridges and narrow gaps. This technique, in combination with full-wave mode matching method has been employed for the design of half-wavelength resonators at the operating frequency [6]. The required couplings between resonators have been determined according to well-established techniques [5].

In the proposed configuration, apart from the parallel couplings between successive resonators 1 (Lr1) and 2 (Lr2) at section Ls12 and 2 (Lr2) and 3 (Lr3) through section Ls23, the 1st (Lr1) and 3rd (Lr3) resonators are also directly cross-coupled in series through the septum Ls13 between them. This accounts for a finite transmission zero. Optimisation of the total structure has been made at the last stage of the design in order to ensure the specified return loss and the posititioning of the transmission zero at the upper cutoff for sharp roll-off. A Transmission Line Modelling (TLM) based software (Microstripes, by Flomerics) [7] has been employed for this final stage of the design

III. 3RD ORDER FILTER

In order to demonstrate the performance of the proposed structure, a 3rd order filter has been considered (Figure 1) as an example, with centre frequency at 9.0GHz and a 0.8GHz wide passband with 0.5 dB ripple.

The filter has been designed and fabricated. Dimensions are given in Table 1. The simulated and measured results are shown in Figure 2. A picture of the fabricated prototype metal insert is shown in Figure 3. Good agreement between simulation and measurement has been achieved. Slight discrepancies are due to mechanical tolerances of the fabricate prototype, which was built using mechanical etching [6]. The total dimension of the filter is 35.0mm, corresponding to nearly 50% the size of a conventional E-plane filter with same specifications. The upper 3dB cut-off frequency is at 9.49GHz and more than

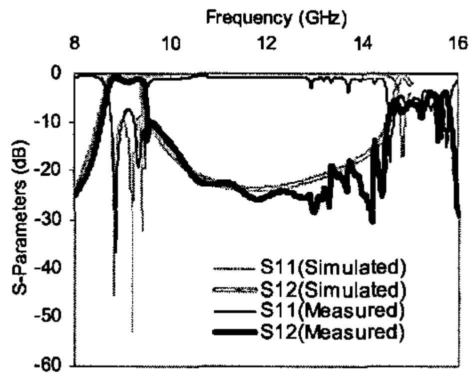

Fig. 2. Simulated and measured response of designed filter with dimensions given in Table 1

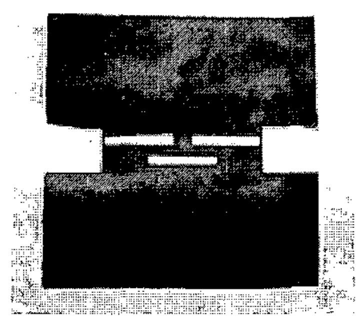

Fig. 3 Photograph of fabricated prototype

10dB attenuation has been achieved at 9.5GHz due to the finite transmission zero.

IV. Conclusion

A novel 3rd order parallel-coupled ridge waveguide filter has been presented. Miniaturisation to about 50% has been achieved upon parallel coupling of the narrow gap resonators. Moreover this topology allows for cross coupling between the 1st and 3rd resonators and a finite transmission zero has been used to achieve sharp upper cutoff. The proposed topology maintains the simple fabrication process of standard E-plane filters. A prototype has been designed, fabricated and measured. Very good agreement between measurement and simulation has been obtained.

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