Wideband Three-Way Cavity Filtering Crossover Array

Sai-Wai Wong (1), Jing-Yu Lin* (2), Guo-Wen Chen(1), Lin Wang(1), Zhi-Min Du(1), Long Zhang(1), Yang Yang(2) and Yejun He(1)
(1) College of Electrical and Information Engineering, Shenzhen University, Shenzhen City, China
(2) School of Electrical and Data Engineering, University of Technology Sydney, Ultimo, Sydney, Australia
Email: wongsaiwai@ieee.org, L.J.2014@ieee.org *, guowenchen7016@qq.com, 1149844375@qq.com, duzhimin2019@email.szu.edu.cn, long.zhang@szu.edu.cn, yang.yang-1@uts.edu.au and heyejun@126.com

***Abstract*—In this paper, a 7th-order cavity filtering crossover with three intersecting channels is presented. Three fundamental modes in one cavity resonator, namely TE_{011}, TE_{101}, and TM_{110}, are adopted to control three frequency channels, respectively. Each channel of proposed crossover resonates at 3 GHz with the fractional bandwidth of 24%. Due to the modal orthogonality of three fundamental modes, good isolation among channels can be easily achieved with the level of 50 dB. Finally, the proposed design can be extended into 3×3×3 crossover array.**

Keywords—wideband, triple-mode resonator, crossover, rectangular waveguide.

I. INTRODUCTION

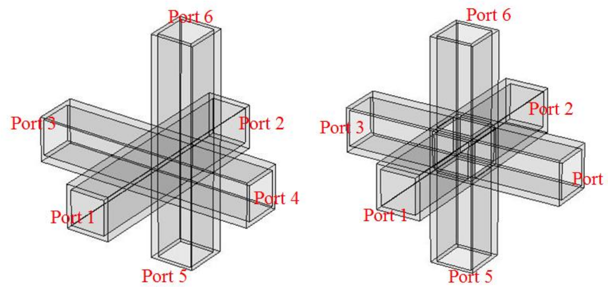
Crossover [1]-[2] is a kind of essential component permitting different signals to cross each other without mutual interference between them. Traditionally, three waveguide transmission lines need to be physically separated when they cross over to each other, as shown in Fig. 1(a). However, when crossover component is adopted, three waveguides can pass through without interaction in the proposed integrated circuit, as shown in Fig. 1(b). By using this method the circuit volume and design complexity can be significantly reduced.

There are several literatures focusing on the cavity/dielectric resonator (DR) crossover. In [3], a two-way DR crossover is proposed by using two pairs of HEH_{11} and HEE_{11} modes. 2nd-order filtering response with three transmission zeros (TZs) is achieved. In [4], three-way filtering cavity crossovers are presented with good isolation, while narrow-band and wide-band cases are designed separately to verify the design methodology.

Due to the advantages of independent controllable frequencies and modal orthogonality among them, three fundamental modes in one cavity resonator are adopted to design some compact waveguide circuits [5]-[6]. In this paper, a wide-band 7th-order filtering crossover using three fundamental modes is designed. A 3×3×3 crossover array with high isolation is presented.

II. 7TH-ORDER WIDEBAND FILTER

First, Each way of proposed filtering crossover array should be analyzed. Due to absolute identity of each of three ways, we take TM_{110} mode as an example, as its analytical approach is similar to TE_{011} and TE_{101} modes. Fig. 2(a) presents the physical model of proposed 7th-order wideband filter based on TM_{110} mode. It comprises three cavities and four slots, while long-side direction of slots is parallel to *x*-axis. WR 284 is used



(a) (b)

Fig. 1. (a) Three waveguides are not in one circuit, (b) three waveguides are in one circuit.

to feed the structure. As explained in detailed in [4], the slots between ports and cavities, the slots between cavities, are considered as four resonant windows. Hence, three cavities (cavity 1, cavity 2, and cavity 3) and four slots (slot 1, slot 2, slot 3, slot 4) resonate at a wide passband. For the specification of filter with fractional bandwidth of 24% at 3 GHz, the formulas (1) are used to extracted external quality factor (Q_e) and coupling coefficient (K):

$$Q_e = \frac{2\pi f_0 \tau_{s11}(f_0)}{4} \qquad K = \frac{f_{p2}^2 - f_{p1}^2}{f_{p2}^2 + f_{p1}^2} \tag{1}$$

Where $\tau_{S_{11}}(f_0)$ represents the group delay at the resonance, f_0, f_{p1} and f_{p2} represent the two resonant peaks. The extracted values are Q_e=2.9, K_{12}=0.11, K_{23}=0.13, respectively. Fig. 2(b) gives a simulated S-parameter curves of proposed structure. It resonates at the center frequency of 3 GHz with 720 MHz bandwidth.

III. 3×3×3 CROSSOVER ARRAY

Since the modal orthogonality among three fundamental modes [4], it is easy to achieve three ways of crossover array and there is no interaction among different ways. Fig. 3(a) presents the physical model of 3×3×3 filtering crossover array. It consists of 27 cavities, 54 waveguide ports, and 108 slots. Therefore, it totally includes 27 ways in the proposed crossover array design. Fig. 3(a) marks 27 ports, it can be divided into 3 categories:

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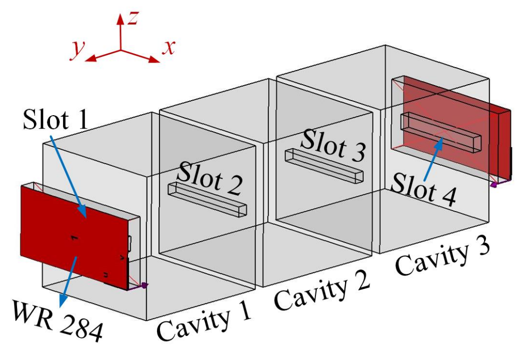
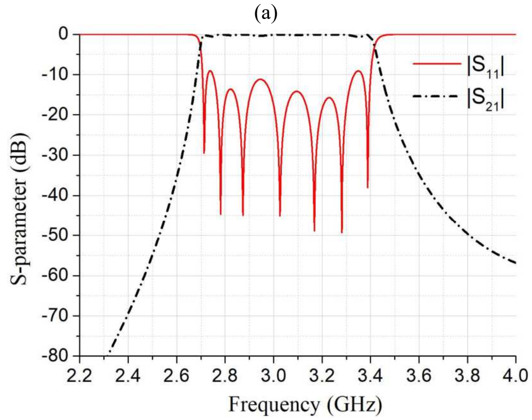
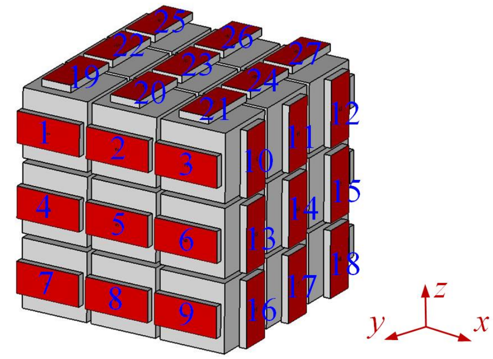


(a)

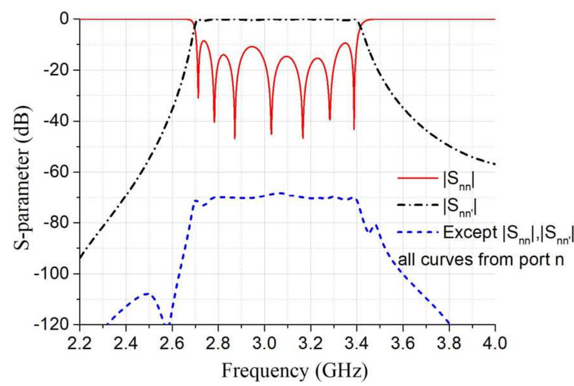


(b)

Fig. 2. 7th-order wideband filter with: (a) physical model, (b) S-parameter response.



(a)



(b)

Fig. 3. 7th-order wideband filtering crossover array with: (a) physical model, (b) S-parameter response.

1) TM_{110} mode: port 1 - port 9;
2) TE_{101} mode: port 10 – port 18;
3) TE_{011} mode: port 19 – port 27.

Three fundamental modes in each cavity are excited and controlled by different waveguide ports, respectively. For example, the cavity connected with port 3, port 10, and port 21 includes three fundamental modes. Port 3 excites TM_{110} mode and pass it through two more cavities and finally to port 3'. Similarly, port 10 excites and passes TE_{101} mode while port 21 excites and passes TE_{011} mode.

Fig. 3(b) shows the S-parameter curves of the proposed structure. *n* represents the port number 1 - 27, *n*' represents their respective port. It can be seen that in Fig. 3(b), the electromagnetic (EM) waves excited by port *n* will only be transmitted into its respective port *n*', and isolated from other ports. The isolation level can reach 50 dB.

IV. Conclusion

In this paper, a 7th-order wideband filter is presented using one of three fundamental modes. Based on the modal orthogonality of three fundamental modes, it can be extended into a 3×3×3 filtering crossover array. It possesses 24% fractional bandwidth at 3 GHz, the isolation level among channels can achieve 50 dB.

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