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Sinusoidally Modulated Cavity Loaded Substrate Integrated Waveguide Wide Band Pass Filter

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Abstract:
This work proposed a sinusoidally modulated substrate integrated cavity loaded substrate integrated waveguide (SIW) band pass filter. The field components of the unloaded sinusoidally modulated substrate integrated waveguide are discussed. The width of the periodic structure is a function of the modulation index of the sinusoidally modulated SIW. The periodic structure shows the filter-like property, the filter-like property of the sinusoidally modulated SIW is discussed. The band width of this periodic structure is increased by loading this periodic structure with cavities.
Key Words: *Periodic, Sinusoidally, SIW*

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I. Introduction

Recently, radio communication (RF) communication components have attracted a lot of interest. With each passing year, new applications are proposed, investigated, and successfully implemented. In many microwave and RF applications, filters are essential. Microwave and RF filters are faced with increasingly demanding requirements from emerging applications like wireless communication systems [1, 2].

In this work we design a sinusoidally modulated SIW filter loaded with the cavities. S –parameters are compared with the unloaded sinusoidally modulated SIW. The proposed sinusoidally modulated cavity loaded filter has the wide band width, which is useful in the X and Ku bands and other millimeter wave applications.

SIW technology is regarded as one of the most appropriate options for developing RF components [3. 4]. SIWs are quasi-waveguides made up of two parallel copper sheets joined together by rows of shorting pins on each side. The benefits of a non-planar bulky waveguide are realized through planar SIW technology, which allows the non-planar component (waveguide) to be integrated with planar circuits such as a printed circuit board (PCB) and low-temperature co-fired ceramic (LTCC). SIW structure dispersion characteristics and field patterns are similar to classical non-planar waveguides. SIW exhibits the majority of the classical waveguide properties, such as high power handling capability and high quality factor. SIW structures' planar structure and integration with other planar circuits is one of their most significant advantages [5, 6].L. Silvestri et al. [7] designed SIW filters built on recurring holes in the dielectric layer. The perforations enable the local effective dielectric permittivity to be reduced. J Martinez et al. [8] proposed two different topologies of S-band band-pass filters based on periodic structures in SIW technology that are theoretically and experimentally addressed. The first topology consists of periodic rectangular perforations of the SIW substrate. D. Lopez et al.'s [9] design, a band-pass filter, based on an Electromagnetic Band-Gap (EBG) waveguide in SIW technology periodically perforated with rectangular holes, is successfully addressed. Kumar et al. [10] designed a sinusoidally modulated SIW for the different values of the modulation index. The propagation constant and the field's components are also derived.

In this paper, we create a sinusoidally modulated SIW filter that is loaded with cavities. The S–parameters are compared with the unloaded sinusoidally modulated SIW. The proposed sinusoidally modulated cavity loaded filter has a wide band width, which is useful in the X and Ku bands and other millimeter wave applications.

II. Filter Design and Analysis

Figure 1 depicts a three-dimensional (3D) diagram of substrate integrated waveguides with designed sinusoidal changing widths loaded with cavity. The SIW has a length of 30 mm and a width that varies sinusoidally depending on the value of the modulation index. The SIW and traditional rectangular waveguide both have similar transmission and distribution properties. In these designs, a substrate made of RO 4350B with a relative dielectric constant of 3.48 and a height of 0.762 mm is used. The diameter of the vias is 0.61 mm, while the distance between them is 0.91 mm. The modulation index of the SIW is calculated from the following formula[10].

$$\mu = \frac{W_{max} - W_{min}}{W_{max} + W_{min}} \qquad (1)$$

where, W_{max} and W_{min} are the minimum and maximum widths of the loaded and unloaded SIW.

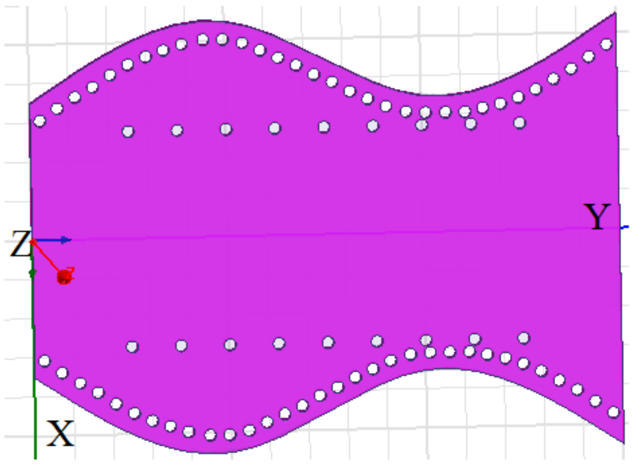

Figure 1. Cavity loaded SIW in rectangular coordinates.

The value of the modulation index is 0.246 for the proposed SIW filter. The longitudinal distance between the probes of the cavity is less than $\frac{\lambda}{10}$, which making it resonates at the higher frequencies.

III. Analysis and Results

As the structure with is function of the modulation index μ than for the analysis a new orthogonal coordinate system is designed. The transformed coordinates in new coordinates systems are u_1, u_2, u_3 are as follows [10]

$$u_1 = \frac{x}{1+\mu f\left(\frac{2\pi y}{p}\right)} \qquad (2)$$

$$u_2 = y + \Delta(x, y) \qquad (3)$$

$$u_3 = z \qquad (4)$$

Where, $f\left(\frac{2\pi y}{p}\right)$ is function of y coordinates and periodicity p, The derived electric and magnetic fields components along the axis of the SIW are as follows [10].

$$E_x = E_y = H_z = 0 \qquad (5)$$

$$E_z = -j\omega\mu U_2,\ H_x = \frac{\partial U_2}{\partial y} \qquad (6)$$

Here, U_2 is a function of the u_2 coordinate only.

The S-parameters comparison curve for the proposed cavity loaded sinusoidally modulated SIW with unloaded sinusoidally modulated as in [10] shown in Fig. 2

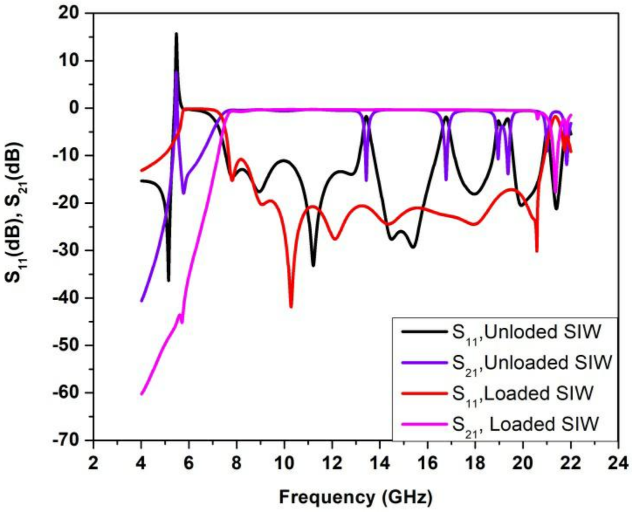

Figure 2. S parameters Comparison curve of loaded and unloaded SIW

The unloaded sinusoidally modulated SIW shows the multi-band, band pass filter with negligible insertion loss. If the iris cavity is loaded, then the band width is increased, and the intermediate stop band deteriotes. The pass band occurs from 8 GHz to 22 GHz with almost negligible insertion loss.

IV. Conclusions

In this work, a sinusoidally modulated substrate integrated cavity loaded band pass filter has been designed and simulated. The designed filter has a wide band width, which can be used in X, Ku band, and millimeter wave applications. The field components of the unloaded structure are also discussed.

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