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Review on Various Issues and Design Topologies of Edge Coupled Coplanar Waveguide Filters

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Abstract
In this paper, we put forward the literature review related to filter design issues and various design topologies to implement the practical edge coupled coplanar waveguide filters. One of the main objectives of this survey paper to find out the comparison between various designs topologies on the basis of several parameters like providing flexibility to minimize analysis complexity, bandwidth and size reduction of edge coupled coplanar waveguide filters without loss of accuracy. Another objective is to provide the novel approach in order to help a researcher to find the suitable edge coupled coplanar waveguide filter design topologies.

Keywords- Bandwidth, Edge Coupled Coplanar Waveguide Filters, Topologies.

1. Introduction

The rapid development in the communication systems, increases the demand for high performance and compact systems which satisfy the requirements, especially at microwave and millimeter frequency range. To meet this demand, MMIC technology has shown a trend towards coplanar waveguide because of some considerable features like the realization of balance circuit, wide range of impedance and possibility of both series and shunt connection without requiring via holes offered by this waveguide. The coupled coplanar waveguide structure is a useful component with many high frequencies applications for MIC and MMIC circuits. The various topologies for used of coupled coplanar waveguide structures of design of band pass filter are reported like an end coupled coplanar waveguide filters, parallel coupled coplanar waveguide filters and edge coupled coplanar waveguide filters (Batmanov et al., 2007; Gao and Zhu, 2004; Guglielmi and Melcon, 1995; Kumar and Gowri, 2016; Lin et al., 1995; Menzel et al., 1995; Nguyen, 1992; Park et al., 1998; Wu et al., 2005, Kuo et al., 2004, Line et al., 2005). The structure of an end coupled coplanar waveguide and edge coupled coplanar waveguide structure shown in Figure 1. In an end coupled resonator's energy inter change with the coupling gap are insufficient, even when very small gaps are employed. The problems of dimension tolerances and sensitivity are also unduly severed. Due to this reason parallel or edge coupled coplanar waveguide resonators are more commonly used than end coupled coplanar waveguide (Matthaei et al., 1963; Matthaei, 1963). Edge coupled coplanar waveguide structure of less cross talks, the low dispersion, high isolation, high coupling factor and balanced circuits, wide range of impedance large bandwidth and high directivity provide suitable environment to design of the filters, couplers and power dividers (Liao and Chen, 2000; Singkornrat and Buck, 1991; Zhu and Wu, 2006).

In this coupled configuration, due to symmetry of the structure, the problems may be separated into two problems using an even/odd mode analysis and electric field configuration in the coplanar slots are formed, it solved the problem involve in connecting the shunt element between the conducting and ground strips; a result's reliability by increased reproducibility is enhanced and product cost is decreased.

In an end coupled filter it is difficult to achieve large coupling due to limitations on gap width implementation so the end coupled filters are suitable to narrow band filters (Lin and Wu, 1997). The direct coupled coplanar waveguide filters to eliminate the capacitive coupled resonator which reduces radiation loss. It retains high Q performance, which helps design filters with low insertion loss and good stopband (Everard et al., 1993; Lin and Cheng, 2007). In Edge coupled coplanar waveguide filters it is easy to achieve desire bandwidth by the tight line to line spacing, and it also exhibited attractive characteristics in terms of miniaturization, return loss, insertion loss, selectivity and the suppression of spurious frequency bands (Simons, 2001; Wolff, 2006).

2. Issues Related Edge Coupled Coplanar Waveguide Filters

There are various issues with an edge coupled coplanar waveguide like frequency shifting, discontinuities' effect, mode conversion and need of tight coupling. In the design process of edge coupled coplanar waveguide filter discontinuities play a major roll because it is the presence of width stepped discontinuity, open discontinuity and sometime gap discontinuity.

2.1 The frequency shifting is one of the main drawbacks of edge coupled coplanar waveguide filters. The shifting in frequency due to end capacitance appeared at open end making the length of the coupler electrical longer so that the actual length of the coupler shorted by the amount of.

$$L_{J,J+1} = 0.165 \times S \quad (1)$$

Where S is the separation between conduction strips and ground plan (Cohn, 2000; Edwards, 1981).

2.2 In the edge coupled coplanar waveguide filters, end coupled discontinuity and asymmetric width discontinuity affects the response of filter. For compensating this effect air bridge and bond wires is placed at discontinuities for ground equalization, which increases circuit complexity and radiation losses.

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3. Various Filters Design Topologies

There are several topologies which are used for design and analyze the edge coupled coplanar waveguide filters.

This topology consists symmetric coupled slots at the center of the coplanar waveguide line and "inside-out" and "outside-in" configuration (Weller, 2000). This technique provides compact and discontinuities free straight forward filter design. First step in design processes to applying Fourier's difference integral equation to calculate the even and odd mode characteristic impedance and conversion to dual quantities. The coupled slot width of each section is not equal so to satisfy the image impedance at each port equal aspect ratios are maintained by

$$\frac{S_1}{S_1 - 2W_1} = \frac{S_2}{S_2 - 2W_2} \tag{2}$$

After satisfaction with equations (2), JZ_0 is determined for corresponding dual geometry and then this process repeat of range of coupled section to find the design curve. By considering the design curve the design equations are select to find the geometry of filter.

Next topology of edge coupled coplanar waveguide filter design with floating strips (Cheng and Shiu, 2000). These floating strips are placed below to couple resonators to increase the coupling coefficient level. In this design, the width of all resonators can be same by variation in floating strips. This approach helps to reduce the discontinuity's effect and radiation loss both. This topology worked on the idea of increases the coupled coefficient level and tries to make the even and odd mode propagation equal as possible as. For this floating strips add on every section of coupled resonators and examine the single coupled section S-parameter by well-known S-parameter equation.

$$S_{11} = S_{22} = \pm\left[\frac{1 - C^2 - C^2 \sin\theta}{(\cos 2\theta - c^2 \cos^2\theta) + j\sqrt{1 - C^2}\sin 2\theta}\right] \tag{3}$$

$$S_{12} = S_{21} = \pm\left[\frac{j2C\sqrt{1 - C^2}\sin\theta}{\cos 2\theta - c^2\cos^2\theta + j\sqrt{1 - C^2}\sin 2\theta}\right] \tag{4}$$

Where θ electrical length and C is coupling coefficient

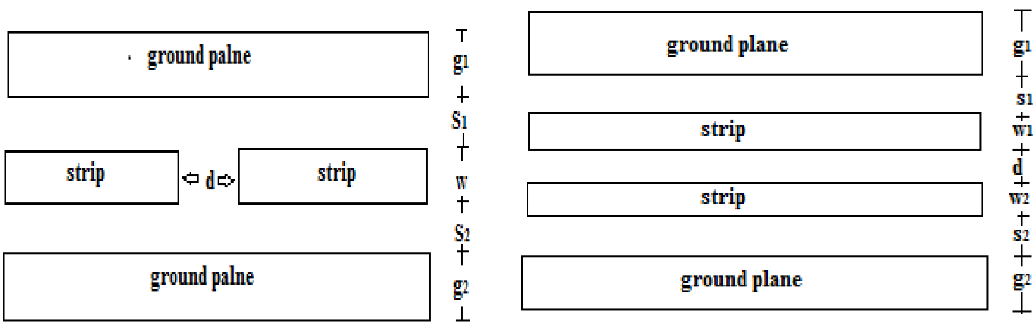
$$C = \frac{Z_e - Z_o}{Z_e + Z_o} \tag{5}$$

The adding of floating strips increase coupling coefficient which makes odd and even mode propagation constant equals which suppress the spurious response and also increase the Bandwidth of filter. With this coupling coefficient every section of filter analyses and then for filter multi-section S parameters are calculated by Manson’s rule.

In this section, two topologies are discussing one edge coupled coplanar waveguide filter with bonds wires and air bridges and other edge coupled coplanar waveguide with finite ground plane. These two filters designs use conventional coupled resonator equations for calculation of dimensions. The wider air bridges lower air bridge and bond wires is used for ground equalization which suppressed of discontinuities effect and improve the filters response (Kovero, 2002). These bond wires are place in two different ways first at discontinuities and secondly at middle of coupled line. The insertion loss of filter is decreasing to the used of bonds wire at discontinuities because the excitation of radiating coupled slot mode and mode conversion is prevented more effectively which make passes band response more symmetric mode. The coplanar waveguide edge coupled band pass filter with finite ground plane compare the resulted of two filters with thin ground plane and wider ground plane (Usyal, 1997). This comparison show that wide ground placed to introduce more attenuation in pass band of filter and the ground should not less than 5mm. It also shows that with careful calculation and right optimization, an edge coupled coplanar waveguide filters coupled be design without bonds wires and air bridges.

4. Conclusion

The filters design with coupled slots, dual geometry and floating strips give symmetric response, free from discontinuities effect, no requirements of bond wire and air bridges but process of analysis and design implementation is complicated. The difference between theses one suitable for narrow band filters and other for wide band filters. To improve the design of high frequency edge coupled coplanar waveguide filters performance, use of bond wire and Air Bridge are better option. The edge coupled coplanar waveguide filters with wide ground plane is providing simple design calculation, symmetric and high performance results. This review paper discusses various issues and several topologies for edge coupled coplanar waveguide filter design.



(a) (b)

Figure 1. (a) End coupled coplanar waveguide (b) Edge coupled coplanar waveguide

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