Using Electromagnetic Band-gap Structure to eliminate frequency multiplication Noise and implement 3D Band-pass filter on Testing Load Board

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Abstract

In order to reduce the cost on the test load board design, and offer the varible pass-band center frequency. This research design a tunable embedded filter [1]. And embedded electromagnetic band-gap in the band-pass filter. The purpose is to eliminate multiplication noise [7] and provide variable band pass filter specifications and spiral electromagnetic band-gap structure.

Introduction

A common problem which use embedded passive device in the substrate, frequency multiplication can not to eliminate signal noise. This study designs a band-pass filter by semiconductor process specification currently [1], and uses the electromagnetic band-gap structure to solve frequency multiplication signal noise problem.

Band-pass filter is designed by four layers load board. The first layer is a 50 Ohm ideal transmission line, the second layers is electromagnetic band-gap, the third layer is a reference plane for transmission line, and four layer structures is a complete ground plane.

This paper embedded three via to change the signal pass pathway [3], so high frequency signal pass way will be different with low frequency signal. This way will be produced a band-pass filter, then transmission line reference downward destructive structural plane [1]. A multiple signal noise will be eliminated by the signal return path.

Filter Structure And Design Rules

The vertical structure of proposed embedded filter is shown in Figure 1. Figure 1 shows three through-hole vias. The center via connects all layers; the other vias go through ground plane and connect power plane. This structure emerged different frequency resonances with S-parameter due to two kinds of return path for low or high frequency signal. Therefore, the pass-band is obtained by this structure [1-2].

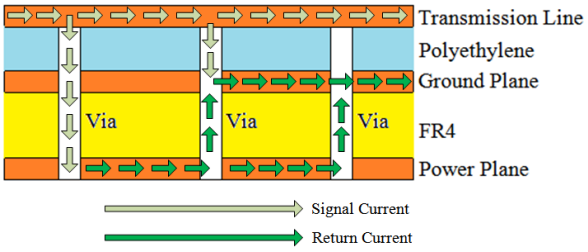

Figure 1 Vertical profile of filter

According to the above method, the initial 3D-structure design and corresponding model is shown in Figure 2.

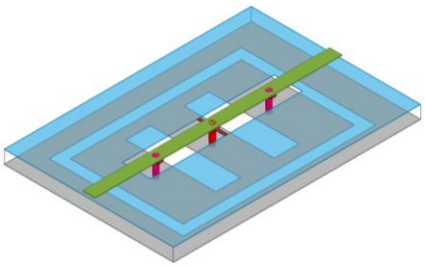

Figure 2 3D-structure of filter

The design rules of filter are built on slot size tuning in ground plane and power plane. Fig. 3 shows design parameters. The slot width and length is m1 and n1in layer2. The layer3 overall structure size is decided on

m2 and n2. There are two rectangular slots in the isolation ring. The rectangular slots are symmetrical. M3 is length and n3 is width for symmetrical slots. Their distance is L. d is the length between isolation ring and rectangular slots [1] [4].

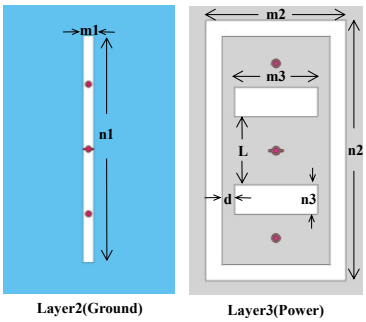

Figure 3 Design of power-ground plane

Tuning the parameters d, m1 and n3 can change bandwidth of filter and n2 affects pass-band frequency. For bandwidth tuning, the selectivity of filter is better when parameter d and m1 at the smallest possible size, but both of them are limited by the process. N3 is the other influence bandwidth parameter. The selectivity of filter is better when n3 is bigger. There is a factor n3 which can adjust pass-band frequency effectively. The result of tuning simulation is shown in TABLE I.

Table 1 simulation result of tuning parameter

Tuning Parameter		Bandwidth @ fc
d	0.15mm	30.1%@2.52GHz
	0.65mm	38.5%@2.70GHz
	1.15mm	42.8%@2.78GHz
m1	1mm	30.1%@2.52GHz
	2mm	52.2%@2.62GHz
	3mm	54.3%@2.57GHz
n3	1mm	35.8%@2.62GHz
	2mm	30.1%@2.52GHz
	3mm	25.1%@2.47GHz
n2	31.9mm	30.1%@1.98GHz
	25.9mm	30.1%@2.52GHz
	19.9mm	30.1%@3.35GHz

Beginning of the research, this paper design a filter with three vias model and the pass-band frequency emerges at 2.5GHz.

Electromagnetic band-gap structure

The common practice to inhibit frequency multiplication noise is to add inductance in RF circuit design. However, testing load board wiring is complex in the semiconductor test industry. One way to embedded inductance in test load board by electromagnetic band gap is planar type. Planar type electromagnetic band gap will be dug two slots to provide a long straight wire on the return path. The wire will be equivalent an inductor at high frequency. But this way makes return path ground too broken, and broken range is too large [6]. If thermal stress be produced, the test load board will produce a fracture case.

In this thesis research the three-dimensional structure of the destructive electromagnetic energy gap. The band-pass filter is designed under a limited area to observe frequency multiplication noise suppression. The method will damage the return path under a smaller area [5], and produce a bigger inductance value [4-5]. This design method not only saved money in the IC test load board design but also saved more PCB area which designer can do electronic components layout. It will be provided better efficiency.

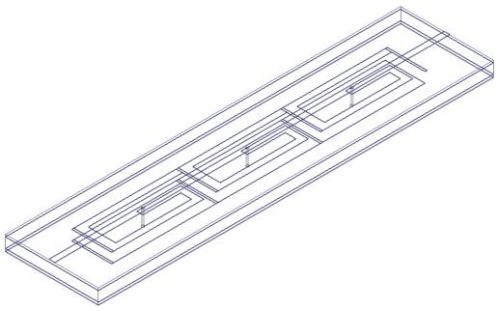

Figure 4 Perspective view of a 3D Band-pass filter overall structure

This paper not only changes the slot size but also embedded the spiral electromagnetic band-gap in layer two. Then papers was improved the filter power plane. Power plane has four slot, tuning the slot size will change the capacitance value [4-5] [8].

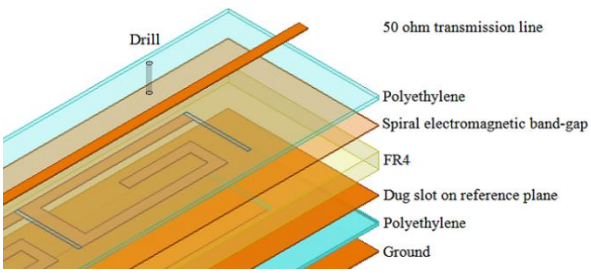

Figure 5 Three-D Band-pass filter cross section

The spiral electromagnetic band-gap provide with inductance values [4] [7] [8].

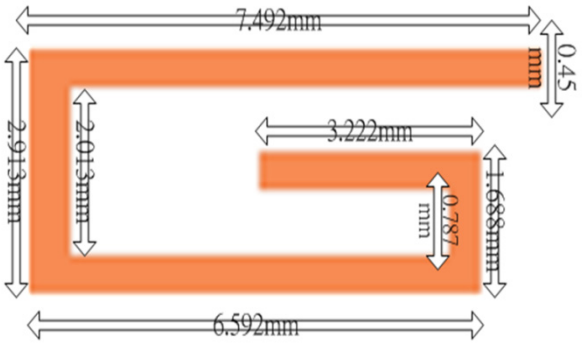

Figure 6 Spiral electromagnetic band-gap scale

Simulation

The simulation result of 2.52GHz filter is shown in Fig. 5. The simulation and measurement frequency bandwidth is from 0.1 to 8GHz. The measurement specification of insertion loss is -1.78dB and return loss is -11.53dB at 2.35GHz. There is noise interference in the 7.5GHz.

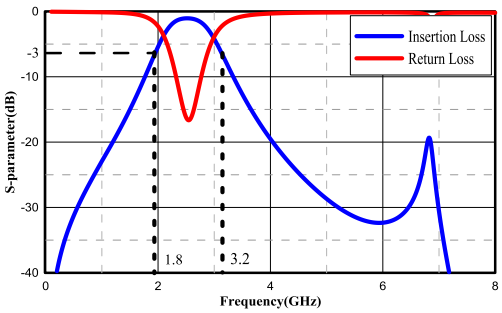

Figure 7 Simulation and measurement of 2.52GHz filter.

The new structure of band-pass filter embedded spiral type electromagnetic band-gap in layer two. And dig slot in layer three. It is improves the multiplication noise in 7.5GHz and 10GHz. And the noise insertion loss under 20dB.

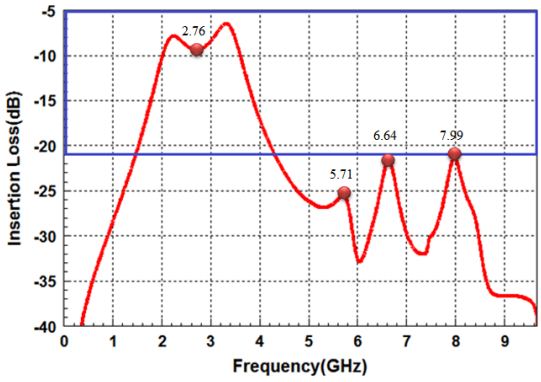

Figure 8 Eliminate frequency multiplication noise

Conclusion and Discuss

The theoretical basis of study was that transmission line was destructed on the ground and power plane. It was provide inductance and the capacitance value on signal return path. According to the microwave engineering theory, the capacitance and inductance producted a resonance when the effect electric in different electrical length. Therefore, embedded electromagnetic band-gap production of embedded passive components which was provided capacitance and inductance value in the test load-board. The multiplication noise resonance [7] will be counteracted when the imaginary part of the capacitance and inductive impedence value equivalent. The resonance point of the noise extends, so that the performance of the filter will be better.

Acknowledgement

This study will be designed a tunable filter structure. First, papers created a design rule of adjusting the ground and power plane specification.

It can be applied in each pass-band, and embedded the electromagnetic band-gap in the slot to change multiplier noise. In the future, the study will produce all kinds of different types of electromagnetic band-gap structure models [9]. And create the circuit model of electromagnetic band-gap. This study hopes to create filter design rules which can design filter quickly and effectively by two-D circuit model simulation. Finally, the requirements of different pass-band frequency will be solved.

References

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