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Design of a Novel Wide Stopband Common Mode Filter with Slotted Ground

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Abstract --- Design of filters for higher frequency ranges often face the limitation of stop band offset which is also a major problem in common mode filters design. Bandwidth enhancement of the stop band offset is the only solution to overcome the issue, in this paper a simple technique has been proposed to enhance stop band bandwidth in common mode filters. Ground slot technique is proposed to expand the bandwidth of stop band. The characteristics of the filter are analyzed by considering a filter model with three conductors. Proposed filter has a stop band bandwidth of 3.3 GHz with an all pass bandwidth of DC to 40GHz. The simulation results of the proposed design verify the performance of the filter. With the proposed ground slot technique the stop band bandwidth of the common mode filter has been increased by fifty percentage without any other problems.

Keywords—common mode filter, ground slot, stopband offset;

I. INTRODUCTION

High-speed digital circuits widely use differential lines for their low sensitivity to noise and electromagnetic interference. Differential signals have a great advantage in the case of serializer and deserializer working at gigahertz frequencies. In real time application, this differential line concept has a drawback of common mode noise which is generated in the differential lines used. This noise generated will have a negative effect on the performance of the device and it causes electromagnetic interference in the input and output cables [1].

Techniques like using high permeability cores in the design of discrete components and ceramics with low temperature coefficient in the design of filters can be used to reduce noise generated in the differential lines but the maximum stop band that can achieved will be 5GHz only. Above techniques can be used for the designing of chokes and filters in the common mode configuration [2-4]. Filters with a printed circuit board base with common mode configuration [5] are been proposed because of their low profile and low cost. Majority of the common mode filters studied used the structures with Electromagnetic Band Gap [6]-[9].In these designs the Electromagnetic Band Gaps were created in the ground plane which are located at top and the bottom sides of the differential lines. The EBG will not allow the noise through it as there will be a coupling between the signal passing through the differential lines and the operating frequency of the EBG structure [10]. A real-time problem with the integrated common mode filters is the misalignment in between the differential lines and filter [11]. Whenever there is a change in the PCB layer the symmetry of the filter will be degraded and it results in an offset of the operating frequency of the filter and increases the common mode conversion ratio. So for high-density interconnections, we will use common mode filters where the co planar differential lines and the filter are on the same layer of the PCB. These types of coplanar common mode filters are insensitive to misalignment issues which generally arise in PCB laminations.

Coplanar common mode filter, being a resonant structure have a narrow stop band bandwidth and it cannot cover the complete noise spectrum sufficiently. Frequency offset is another major issue of concern which is observed at high frequency of operations. These issues are generated because of the non uniform distribution of the dielectric substrate. One of the common techniques used to increase the bandwidth is to place the coplanar common mode filters along the differential lines but it results in more consumption of the PCB area. Therefore, a simple bandwidth expansion technique which is easily achievable and of low cost is very essential for the real time applications.

In this communication, a novel technique to increase the stop band bandwidth of a filter in common mode configuration is presented. To study the coupling effect between the differential lines a three conductor model has be considered. Bandwidth expansion approach has been proposed taking into consideration the inter connection between the geometry of the filter and the corresponding coupling levels. This technique includes the optimization of the gap between the filter and the differential lines and also using defective ground structures. Finally a filter in common mode configuration is proposed and by placing a slot in the ground plane we can increase the stop band bandwidth of the filter.

II. DESIGN OF COMMON MODE FILTER

Differential lines are sensitive to the EMI effects from external sources when used for carrying high frequency signals like 10GHz and above. So micro strip lines cannot be used here rather strip lines which have high immunity should be used. A filter functioning in common mode configuration has been studied in this paper. In Fig. 1, a common mode filter with coplanar strip lines is shown. The filter design consists of differential lines, resonator and multiple ground planes. The dimensions used for the filter

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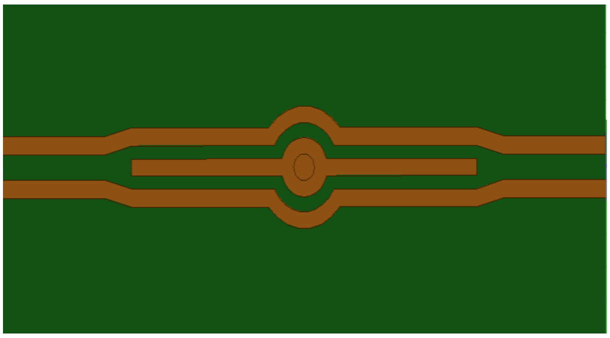
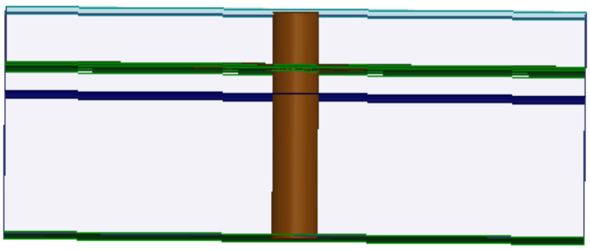
design are given below, width of the co-planar strip lines is taken as 5.4 mil, the space between the co-planar lines is 7.6 mil, width of the center strip line is taken as 5 mil, length of the center strip line is 135 mil, differential lines used in the filter design are separated by a distance of 4 mil, radius of the resonator is 4 mil, radius of the resonator pad is 9 mil, air gap between the GND1 and filter lines is 7.87 mil, air gap between the GND2 and filter lines is 4.71 mil and air gap between the GND2 and GND3 is 19.69 mil. The PCB used here is Megtron6 with a relative permittivity value of 3.3. For the design of the filter a configuration with three ground planes is considered. The center line acts as a electric wall for differential signals which propagate in odd mode and acts as a magnetic wall for the noises generated in the differential lines which travel in the even mode configuration of the filter.

So, there will be no effect on the differential lines even if we place a resonator in the center line which will stop the common mode noise passing through the center line. The major drawback of the coplanar common mode filters is its narrow stop band bandwidth which is the result of weak coupling between the resonator and the differential lines. A resonator is placed in the center of the filter such that it is in the middle of the center strip line and it is necessary to reduce the noise in the filter generated due transmission lines used in the common mode operation of the filter. A simple technique is proposed in this communication for increasing the stop band bandwidth which is discussed in further section.



(a)



(b)

Fig.1. Normal Co-Planar Common mode filter

III. RESULTS & DISCUSSIONS

Common mode filter bandwidth will increase with reduction of mutual coupling in between the coplanar lines. But mutual capacitance between the coplanar lines will increase with reduction of distance between the resonator and the strip lines. So to increase the bandwidth we need to decrease either the self capacitance of the resonator or the self capacitance of the strip lines which is only possible with the increase in the distance between the ground planes which is also not a viable option in PCB's. It will also influence other components that are been placed on the same PCB. In this communication, a simple technique is proposed to enhance the stop band bandwidth of the common mode filter by removing a portion of the ground plane at the center of the differential lines. In the ground plane a rectangular slot of dimension 67.5mil×116.875mil is etched. By this action the reference ground has been shifted from GND 2 to GND 3, which in-turn increases the distance between the differential lines and the ground plane which is considered as reference. This will also increase the coupling levels in the strip lines used for transmission. Figure 2 shows the common mode filter with slotted ground plane.

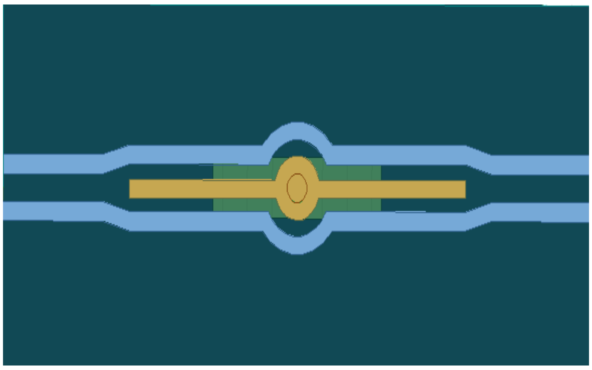


Fig.2. Co-Planar Common mode filter with ground slot

The stop band response of the normal filter is shown in the figure 3, observed a stop band bandwidth of 2.1GHz and a all pass band width from DC to 40 GHz.

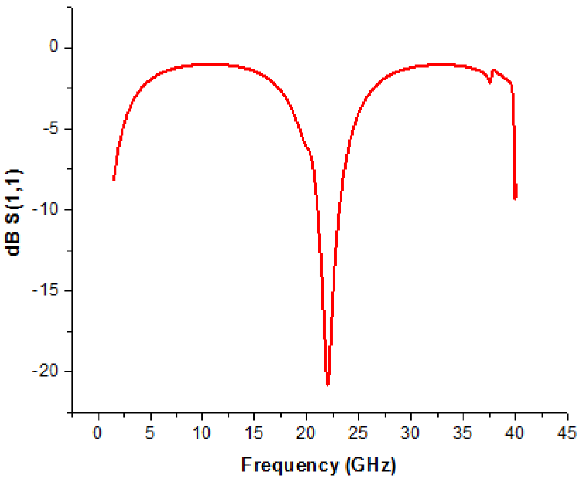


Fig.3. Stop band Bandwidth of normal filter

The stop band response of the filter with a slot etched in the ground plane is shown in the figure 4, observed a stop band bandwidth of 3.3 GHz. From the result it can be clearly observed that the stop band bandwidth of the filter has been increased by more than 50 % with the introduction of the slot in the ground plane.

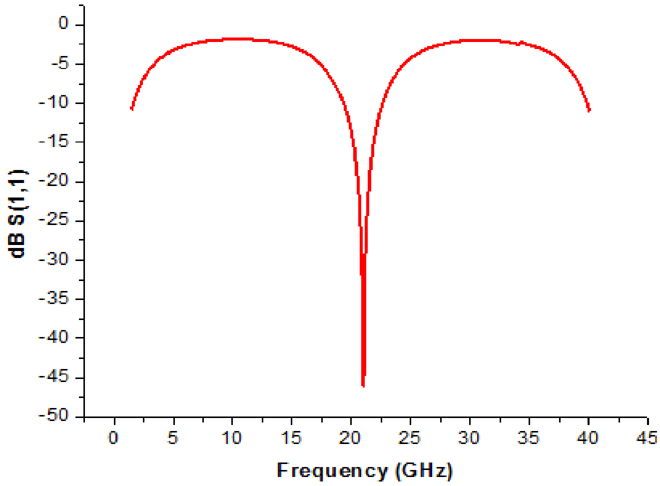


Fig.4. Stop band Bandwidth of Slotted Ground filter

IV. CONCLUSION

A simple technique is proposed to increase the stop band bandwidth of a coplanar common mode filter at high frequencies. With this enhanced bandwidth it is able to overcome the effects of fabrication errors and dielectric material problems. Proposed filter is very useful for the applications where the signals used will be in the range of tens of GHz. The simulation results show that the proposed technique is very effective for improving the bandwidth of the filter. The proposed technique may be extended to other type of filters and resonators.

REFERENCES

1. W. T. Liu, C. H. Tsai, T. W. Han, and T. L. Wu, “An embedded commonmode suppression filter for GHz differential signals using periodic defected ground plane,” IEEE Microw. Wireless Compon. Lett., vol. 18, no. 4, pp. 248–250, Apr. 2008.
2. K. Yanagisawa, F. Zhang, T. Sato, K. Yanagisawa, and Y. Miura, “A new wideband common-mode noise filter consisting of Mn-Zn ferrite core and copper/polyimide tape wound coil,” IEEE Trans. Magn., vol. 41, no. 10, pp. 3571–3573, Oct. 2005.
3. S. Saito, T. Kobayashi, and S. Nitta, “High speed signal transmission compatibility with noise suppression by common mode chokes,” in Proc. 10th Int. EMC Eur. Symp., York, U.K., Sep. 2011, pp. 26–30.
4. B. C. Tseng and L. K. Wu, “Design of miniaturized common-mode filter by multilayer low-temperature co-fired ceramic,” IEEE Trans. Electromagn. Compat., vol. 46, no. 4, pp. 571–579, Nov. 2004.
5. Y. F. Shu, X. C. Wei, X. Q. Yu, Y. S. Li, and E. P. Li, “A compact meander line-resonator hybrid structure for wideband common-mode suppression,” IEEE Trans. Electromagn. Compat., vol. 57, no. 5, pp. 1255–1261, Oct. 2015.
6. S. J. Wu, H. H. Chuang, T. K. Wang, and T. L. Wu, “A novel HU-shaped common-mode filter for GHz differential signals,” in Proc. IEEE Int.Symp. Electromagn. Compat., 2008, pp. 1–4.
7. S. J. Wu, C. H. Tsal, T. L. Wu, and T. Itoh, “A novel wideband common mode suppression filter for gigahertz differential signals using coupled patterned ground structure,” IEEE Trans. Microw. Theory Techn., vol. 57,no. 4, pp. 848–855, Apr. 2009.
8. T. W. Weng, C. H. Tsai, C. H. Chen, D. H. Han, and T. L. Wu, “Synthesis model and design of a common-mode bandstop filter (CM-BSF) with anall-pass characteristic for high-speed differential signals,” IEEE Trans. Microw. Theory Techn. vol. 62, no. 8, pp. 1647–1656, Aug. 2014.
9. F. de Paulis, L. Raimondo, S. Connor, B. Archambeault, and A. Orlandi,“Compact configuration for common mode filter design based on planarelectromagnetic bandgap structures,” IEEE Trans. Electromagn. Compat., vol. 54, no. 3, pp. 646–654, Jun. 2012.
10. F. de Paulis et al., “EBG-based common-mode microstrip and stripline filters: Experimental investigation of performances and crosstalk,” IEEE Trans. Electromagn. Compat., vol. 57, no. 3, pp. 996–1004, Oct. 2015.
11. Q. Liu, S. Xu, and D. Pommerenke, “PCB structures for common mode suppression on differential microstrip lines,” in Proc. IEEE Int. Symp.Electromagn. Compat., 2014, pp. 533–537.

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