Comparative Study of Crosstalk Reduction in Coupled Pair Microstrip Lines using DMS

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***Abstract*—- In this work mitigation of far-end as well as near-end crosstalk in coupled pair microstrip lines (CPMLs) is reported by employing defected microstrip structure (DMS). Different structures like cross shaped, T-shaped and L-shaped structures of DMS-CPMLs are introduced, and their performances in crosstalk reduction are compared. Finally, the configuration showing the minimum crosstalk is designed and simulated. A maximum of 27 dB reduction in far-end and 30 dB reduction in near-end crosstalk are achieved by T-shaped DMS-CPML structure with FR-4 as the substrate and 32 dB in far-end and 33.11 in near-end as TLT as the substrate**

Keywords*— *Defected microstrip structure (DMS); near-end crosstalk; far-end crosstalk; coupled pair microstrip lines (CPMLs);

I. INTRODUCTION

since the mid-1950s Microstrip coupled transmission lines has been used extensively in many microwave circuits and has got vast number of applications including filters, resonators and baluns because they are simple to implement [1,2]. They are used as basic elements for directional couplers, filters, phase shifters and a variety of other useful circuits. [7-9]. A vast amount of articles on these structures exist in the literatures [3-6]. In some applications, such as in coupled line couplers, the coupling effect is desirable, but in some other cases, the coupling phenomenon is undesirable and can degrade the signal quality significantly. So, in these cases, the signal integrity engineers try to reduce the unwanted coupling between coupled lines. As the frequency increases, size of circuit decreases due to compactness of circuits the coupling phenomena comes into picture as coupling increases because of close vicinity of lines. Thus in high frequency circuit design coupling factor has to be considered and the signal trace spacing becomes important for good performance.

Signal integrity or SI is a set of measures of the quality of an electrical signal. Some of the main issues of concern for signal integrity are ringing, crosstalk, ground bounce, distortion, signal loss, and power supply noise among which Crosstalk is one of the main issues of concern for signal integrity. Both far-end and near-end crosstalk should be minimized in coupled lines to keep signal integrity. There are number of crosstalk reduction techniques which are investigated in literatures [10-12]. Some of the methods are difficult and complex to implement, but the proposed technique in this article is very simple and efficient for crosstalk reduction. Various methods like DGS (Defected ground structure), DMS (Defected microstrip structure), Electromagnetic Band gap structure etc are some of the methods used to reduce crosstalk. The proposal for Defected Microstrip Structure is originally given in Refs [13,14].DMS is constructed by removing patterns from the top conductor of a microstrip line. This defect introduces a discontinuity in the line which can produce filtering characteristics. These structures are used in several applications such as filter design, power dividers, amplifiers, antennas, etc. [7-9]. DMS structure is better than DGS structure as DMS circuits are more immune than DGS from crosstalk and ground plane interference. Besides, the DMS is advantageous in high frequency designs. In this article, a novel and simple method for suppression of far-end as well as near-end crosstalk by DMS structures is investigated. It should be noted that the frequency band, in which the near-end crosstalk reduces, is smaller than the frequency band, in which far-end crosstalk reduces. In Section II, is given the structural modeling for analysis and design of T-shaped, L shaped and cross-shaped DMS. In Section III, different structures like L-shaped, T-shaped and cross shaped structure of DMS-coupled pair microstrip lines (CPMLs) are introduced and their abilities for far-end crosstalk reduction and near end crosstalk reduction are compared

II STRUCTURAL MODELING

Full wave analysis is required for the accurate three-dimensional modelling of DMSs as it is not very simple .The microstrip gap may be modelled with a π-network of capacitors, **C**p to ground and **C**gap as the series capacitance, **C**p may be converted into an equivalent line extension Δ(p) or alternatively the p-network could be transformed into an admittance inverter (J-inverter) with admittance **B**g centered between two line extensions Δ(gap).The current path model has been shown in [18] Theoretically calculated data has been given by Silvester and Benedek [16] for a wide range of gap lengths, g, and several values of ε_r, but for only three values of w/h, 0.5, 1, and 2 (h is the substrate's thickness). Equations have been fitted to these data, partly based on the theoretical microstrip model: [18, 19]. Based on the current path, the equivalent circuit of the DMS is extracted [18].It should be noted that the equivalent inductance and capacitance i.e. the value of the resonant elements for DMS structures are extracted from the physical dimensions of the etched defect, gap discontinuity, and the dielectric constant by using very simple equations. [18, 19]DMS structures are shown in Figures below. The substrate used for these structures is Taconic TLT with relative permittivity of 2.55 and thickness of 0.762 mm. Width of the signal trace is 2 mm for 50 ohm impedance, and length of the line is 10 mm. Using the current path model various DMS circuits have been extracted and then using

the equations given in [18, 19] values for L, C, R is being found .Thus various models of T shaped, L shaped and cross shaped DMS can be drawn and their dimensions is being calculated.DMS-CPML STRUCTURES: The modelling steps of the various CPML are presented in [18] and [19].

Table: (a)

Configuration parameter	L Shaped coupled line	T shaped coupled line	cross coupled line
Max(FED) dB	0.12	32	24.11
Max (NED) dB	1.18	33.11	23.73

Different structures of DMS-CPML are shown in Figures 1, 2, 3, 4 below. General CPML structure, T-shaped DMS-CPML, L-Shaped DMS-CPML, and cross shaped DMS-CPML structure having TLT substrate with relative permittivity of 2.55 and thickness of 0.762 mm. Width of the signal trace is 2 mm for 50 Ω impedance, and length of the line is 10 mm. The cross shaped DMS-CPML is shown in fig: 3 having vertical dimension of width 0.2 mm and length 1.164 mm and horizontal dimensions of width 2.3756 mm and length 0.49 mm and also the top dimensions with width 2.3756 mm and length 0.2 mm is designed. Dimensions of T-shaped DMS-CPML is shown in fig: 4 having vertical dimension of width 0.2 mm ,length 1.164 mm and horizontal dimensions of width 2.3756 mm and length 0.49 mm is designed. Similarly L-shaped DMS- CPML having vertical dimension of width 0.2 mm ,length 1.164 mm and horizontal dimensions of width 1.2878 mm and length 0.49 mm shown in fig :2 is designed.

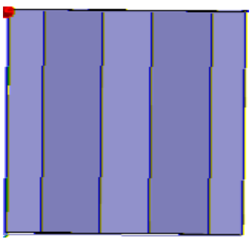

Fig: 1 CPML

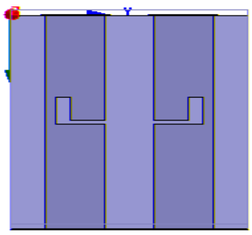

Fig: 2 L shaped DMS-CPML

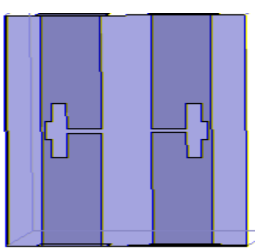

Fig: 3 Cross shaped

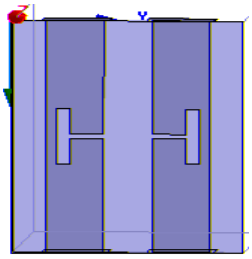

Fig: 4 T shaped

Comparison of all the structures are being done and seen whose performance is better. To evaluate the effect of the relative orientations of DMSs in CPMLs, on far-end and near-end crosstalk, three types of structures are studied for each type of DMS-CPML. In the fig 5 and fig 6 below s11 and s14 comparison of the three structures is shown and found that T -shaped DMS is showing better performance.

III RESULT

The result which we got using TLT as the substrate which showed that the T-shaped structure gives better performance from the above graphs and is thus better. Also the near and far end crosstalk is reduced. But due to the non availability of this substrate, we have performed the experiment on the FR-4 substrate with relative permittivity 4.4 and substrate thickness is taken as 1.6 mm with same dimensions and distance between line is 1.352 mm. As T-shaped DMS-CPML is better in performance, we are going to show its performance experimentally showing the near and far end crosstalk reduction and thus fabricate it finally. Dimensions of T-shaped DMS-CPML having vertical dimension of width 0.2 mm, length 1.164 mm and horizontal dimensions of width 2.5756 mm and length 0.55 mm is designed.

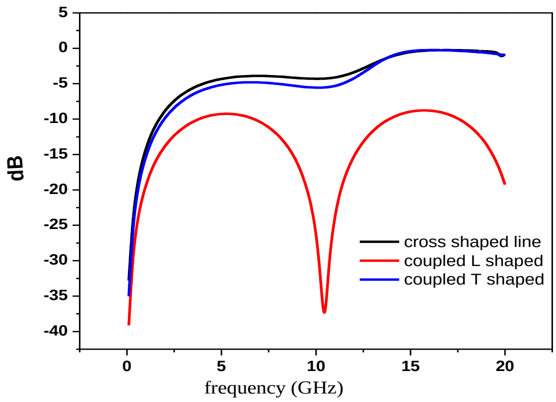

Fig: 5 (S_{11})

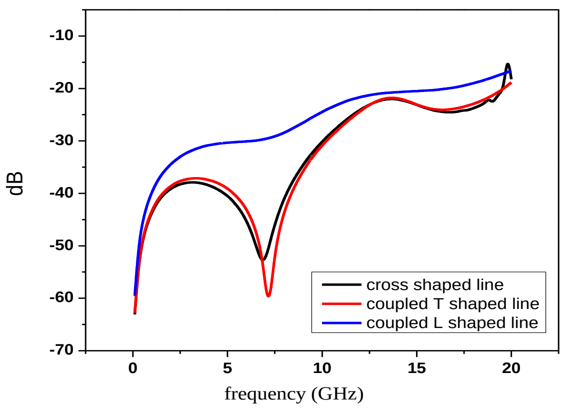

Fig: 6 (S_{14})

COMPARISON BETWEEN THREE DIFFERENT DMS STRUCTURES OF COUPLED TRANSMISSION LINE

Where,

FED = S_{41}DMS_CPMLs - S_{41}ordinary CPMLs (dB)

NED = S_{31}DMS_CPMLs - S_{31}ordinary CPMLs (dB)

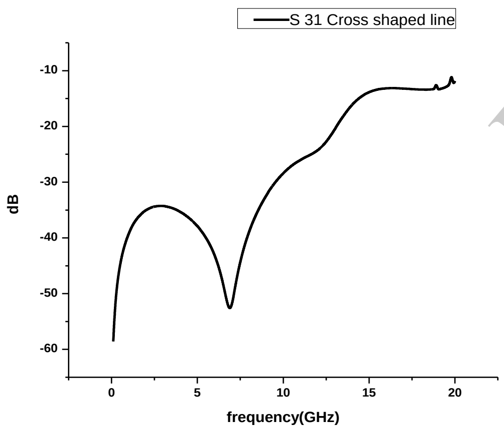

Fig: 7

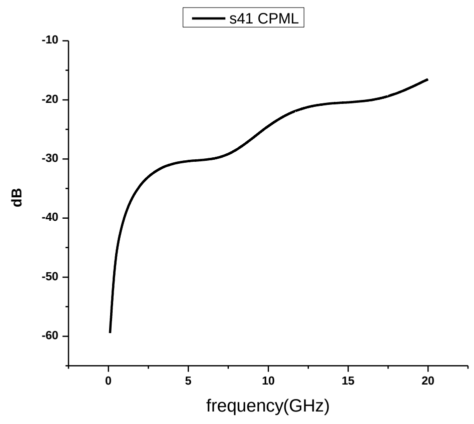

Fig: 8

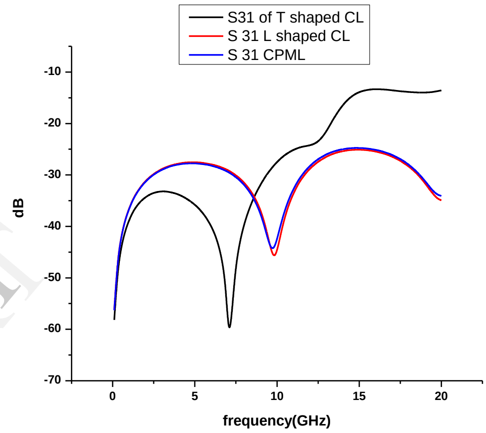

Fig: 9

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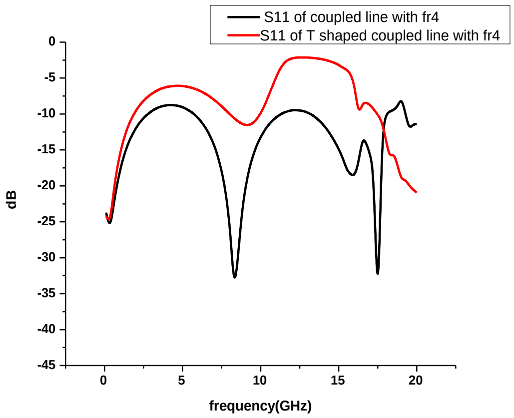

Fig: 10

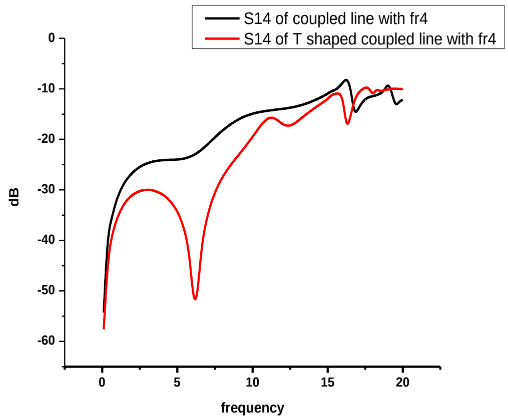

Fig: 11

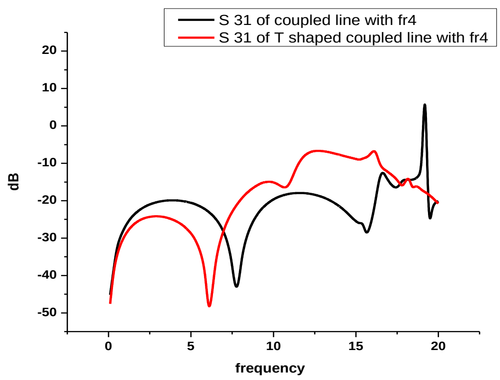

Fig: 12

Configuration parameter	T shaped coupled line
Max(FED) dB	27
Max (NED) dB	30

Where,

FED = S_{41}DMS_CPMLs - S_{41}ordinary CPMLs (dB)

NED = S_{31}DMS_CPMLs - S_{31}ordinary CPMLs (dB)

Above is shown the S_{11} , S_{14} and S_{31} comparisons of normal coupled line with that of T shaped coupled line and also shown the comparison of the near and far end crosstalk of both

IV CONCLUSION

At measurement frequency of 8 GHz with TLT as the substrate we showed that T-shaped DMS-CPML structure is giving the best performance s_{14} as -60 dB. And far-end crosstalk reduction of 32 dB and near end crosstalk reduction of 33.11 dB as calculated and then shown in Table (a). Also with FR-4 as substrate with T shape structure far end crosstalk reduction of 27 dB and near end crosstalk reduction of 30 dB(from Table (b)) is achieved which is accounted as a great achievement in reducing crosstalk

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