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Crosstalk Reduction on Coupled Microstrip To Three Line Coupled Microstrip Transition Using Mitering Configuration

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Abstract

Crosstalk is one of the major signal integrity issues in high speed printed circuits. Generally crosstalk is reduced by means of the guard intervening scheme. In order to reduce crosstalk in coupled microstrip transition, a guard trace is inserted between two lines which inturn to three line coupled microstrip transition. The multimodal analysis involves coupling and transmission of signals travelling through three traces. In this paper, miter bend is proposed to reduce coupling in Coupled Microstrip to Three Line Microstrip Transition. The mitered bend is introduced to reduce crosstalk instead of abrupt bend on a coupled microstrip transition. Mitering bend reduces crosstalk by means of reducing excess capacitance and inductance of the traces which inturn reduce reflections at the bend. Here, the effect of mitered bend at the Three Line Microstrip Transition circuit has been presented in terms of NEXT and FEXT. The simulated results are obtained with the assistance of electromagnetic simulation tool ADS and these results are experimentally validated over the frequency range up to 6 GHz. The measured results are found to be related to thereupon of simulated results. These results show that mitered bend reduces both NEXT and FEXT by 12dB and 3dB respectively more than conventional models.

Keywords: Microstrip lines, Multi modal, Near end crosstalk, Far end crosstalk, Printed circuit board,

Introduction

Printed circuit board plays a significant role in analog and digital electronic systems. Owing to shrinking of PCB size, crosstalk between the traces is inflated. Crosstalk is that the development of that signal on one trace or channel creates associate unwanted impact on adjacent trace or channel. Within the prose, modelling and analysis of coupled interconnections has received substantial attention. Many authors have used multiconductor line theory and analysis of coupled lossy transmission lines. Electromagnetic coupling may be generated when two microstrip lines are adjacent to each other. When the distance between the two lines is large enough, the coupling between these two lines will be weak enough, the affection between the lines can be ignored. But nowadays the speed of the system is getting higher and higher and the area of the PCB is getting smaller and the distance between the transmission lines is getting smaller, so we must get the new solution to reduce coupling. Generally, guard trace is inserted between two lines to reduce crosstalk which is reported and investigated by many authors [1-6]. Crosstalk analysis of the effects of guard trace is presented in [7]. In this paper, a new model is proposed to reduce crosstalk in Multimodal circuit. The coupled microstrip to three-line-microstrip transition is considered for multimodal analysis in which mitered bend is introduced instead of abrupt bend. The effects of mitered bend multimodal circuit with guard trace are analyzed in terms of near end and far end coupling. The simulation results are experimentally validated and comparison shows there is a good agreement between simulated and measured results.

Crosstalk Analysis

Signal integrity may be a major concern in high speed interconnects. Electromagnetic disturbance may be a major issue in signal integrity which is able to have an effect on the potency of the signal being transmitted. At low speeds, the frequency response has very little influence on the signal, unless the transmission medium is especially long [8]. However, as speed will increase, high-frequency effects take over. In order to reduce the magnitude and effect of crosstalk between adjacent transmission lines many design rules and techniques have been widely adopted by high speed PCB designers. Some of them are placing ground /guard trace or plotted through via holes between the adjacent lines, reducing the coupling length, maintaining large enough distance on the order of the substrate thickness between the neighbouring lines or increasing the separation distance from one to three lines, the trace width to alleviate crosstalk between them,etc. [9],[10],[11].

Multimoding may be a development that affects the integrity of a signal because it travels in a line at different speeds. For transmission lines, multimoding happens once there are two or more EM field configurations that may support a propagating wave. The various field configurations travel at different speeds so the signals travel within the two modes can mix incoherently and, if the energy within the two modes is comparable, it will not be possible to pick out supposed data being sent. Figure 1 shows a configuration of a printed circuit board where a signal line is placed close to another signal line. Crosstalk voltages are induced at the far and near ends of the victim line when a signal is propagating in the aggressor line, introducing far end crosstalk (FEXT) and near end crosstalk (NEXT). Thus, designing signal routing with an acceptable crosstalk level is crucial in printed circuit boards.

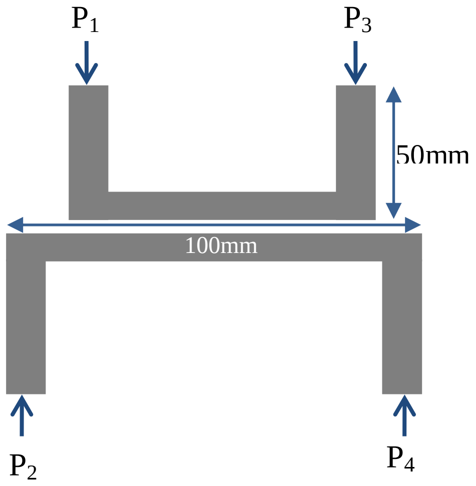
The far-end crosstalk voltage can be represented by

$$V_{fext}=1/2\left(\frac{C_m}{C_T}-\frac{L_m}{L_S}\right).TD.\frac{dV_a(t-TD)}{dt} \qquad (1)$$

where TD is the propagation time through the transmission line. Va(t) is applied voltage at the aggressor line [1].

Far-end crosstalk increases with a sharp rise time, a longer coupling length and a higher Kf factor. In an ideal homogeneous Stripline situation there will be no far-end crosstalk. The far end crosstalk depends capacitive coupling and inductive coupling as expressed in Equation(1).

A guard trace is inserted between these two traces for reducing crosstalk. In this circumstance, the Microstrip to Coupled Microstrip Transition and the Coupled Microstrip to Three Line – Microstrip Transition have been considered. When one of the strips of a coupled microstripline end and the other strip continues as a microstrip transmission line that leads to coupled microstrip transition. The Coupled Microstrip to Three-Line-Microstrip Transition occurs when one strip of a three-line-microstrip section ceases to be parallel to the other two.



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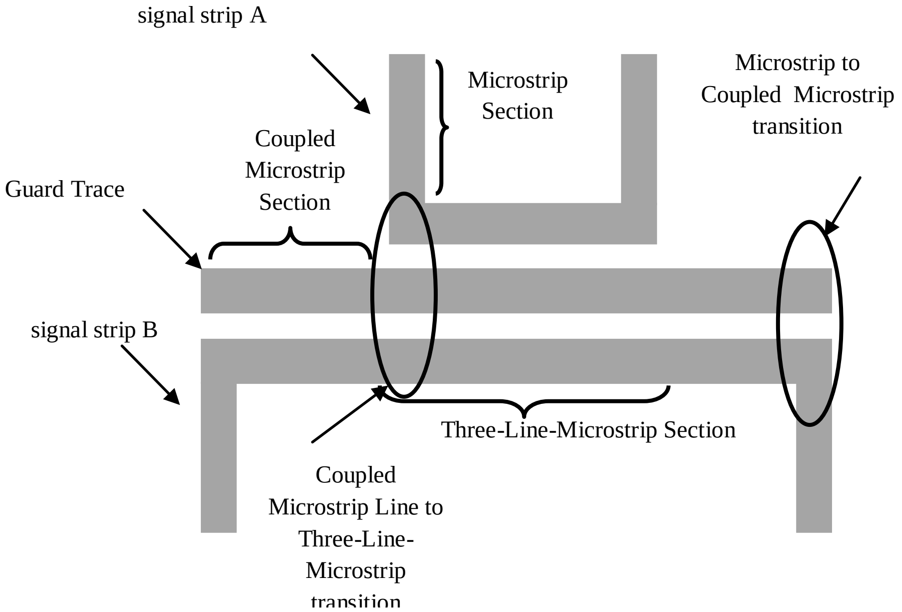


(b)

Figure 1: (a) Coupled Microstrip (b) Microstrip, coupled Microstrip and three-line Microstrip sections

Three different transmission line configurations are involved in these two transitions such as

- The Microstrip transmission line that propagates a Microstrip mode
- The Coupled Microstrip transmission line. It is a multimodal transmission line since it propagates two modes: the coupled Microstrip even mode and the coupled Microstrip odd mode.
- The third transmission line is the Three-Line-Microstrip transmission line. It consists of three parallel conductors (strips) over a ground plane. The Three-Line-Microstrip transmission line is a multimode transmission line since it propagates simultaneously three modes: the ee-mode, the oo-mode and the oe-mode. In order to build a complete multimodal circuit of Microstrip, it is often necessary for the path of a strip to turn through a large angle. In many cases it is necessary to solve the direction change of transmission lines during printed circuit board design. There are three different possibilities for direction change such as right angle, arc and mitered bend.

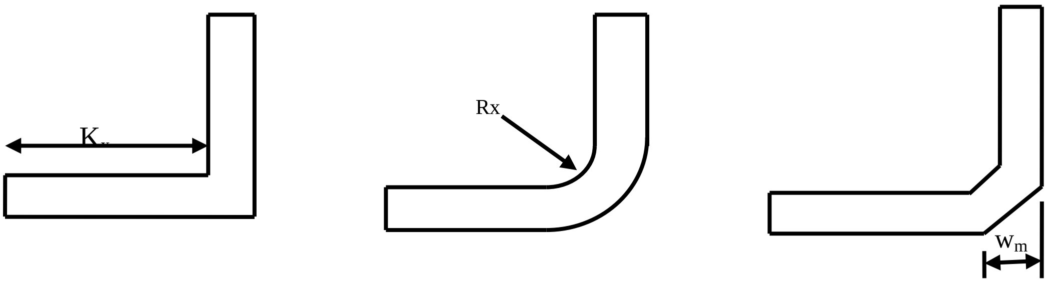
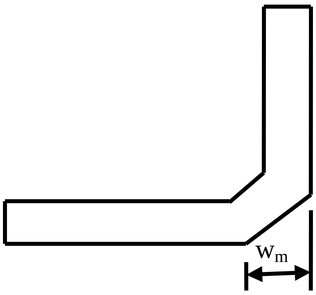


Figure 2: Microstrip Line – Right Angle, Chamfer, Bend

In this work, mitered bend is proposed in the multimodal pattern instead of abrupt bend. The mitered bend configuration is in which half of the metal has been removed from the signal line. The optimum mitered bend (wm) is having an angle of 450 [6]. For a transmission line, the model would relate physical width and length to impedance and electrical length through a set of closed form equations. For a discontinuity like the mitered bend, the physical parameters might be mapped to an equivalent lumped element circuit (Fig.5), again through a set of closed form equations. The mitered bend configuration shown in Figure 3(a) and its equivalent lumped circuit model shown in Figure 3(b). It removes excessive capacitance, which in turn reduces capacitive coupling.



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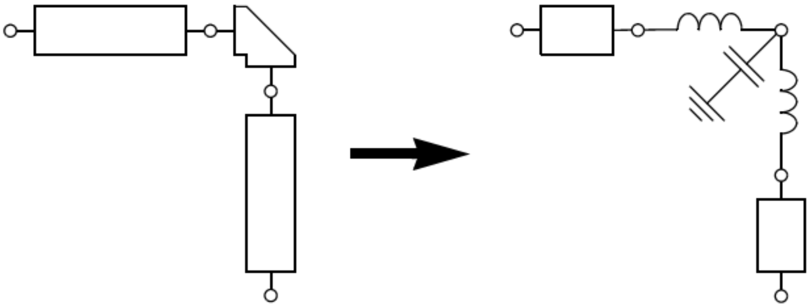


(b)

Figure 3: (a) Mitered Bend Configuration (b) Equivalent Lumped equivalent model

Figure 4 shows the proposed coupled microstrip transition without guard trace. In this structure mitered bend is introduced at the corners of microstrip transmission lines instead of right bend. It helps to reduce capacitance and inductance of the traces which inturn reduces reflections at the corners.

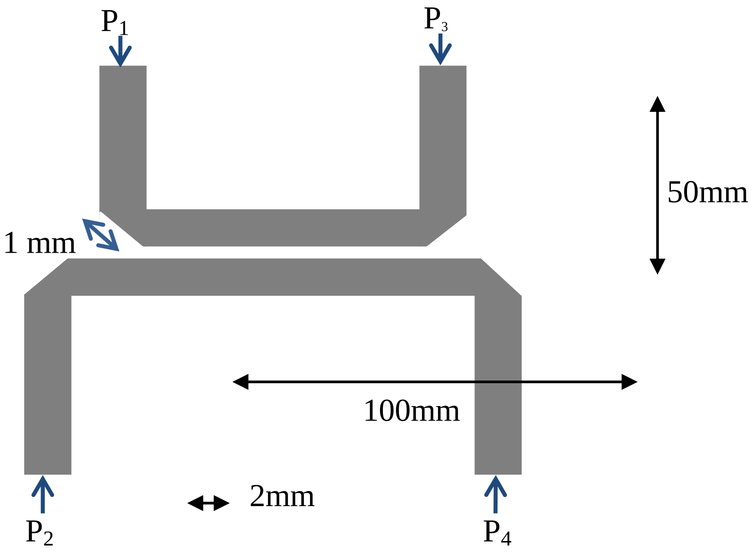


Figure 4: Coupled Microstrip Transition with mitered corners

Mitered corners are also introduced in the Coupled Microstrip – three line microstrip Transition also which is shown in Figure 5. This mitered corners help to reduce reflections at the high frequencies due to the reduction in capacitance and inductance of the traces.

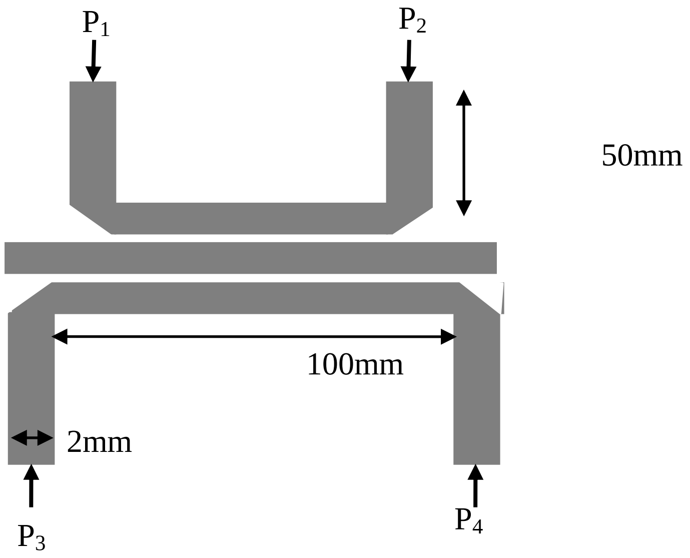


Figure 5: Proposed Model

Simulated and Measured Results

In order to study the effects of mitered bends in Coupled Microstrip transition and Coupled Microstrip to three line transition, several tests have been performed using the circuit of Figure 4 and Figure5. Crosstalk has been analysed over the frequency range up to 6 GHz. The simulated results are experimentally validated.

A. Simulation Results

The physical dimensions of simulated structures are same as given in Fig.1 - Fig.5, and these structures are simulated using ADS (Advanced Design System). The microstrip sections have a length of 50 mm, the coupled microstrip sections have a length of 25 mm and the three line microstrip section has a length of 50 mm. The traces have a width of 1.5mm and the separation between them is 0.2 mm. The substrate used is an FR4 with a thickness of 1.6 mm and εr=4. 6, and the mitered edge length is 1mm.

In this simulation, the coupled microstrip transition can be treated as a symmetrical four port networks. An input signal is applied at port 1 and other ports are terminated by 50 ohm impedance. Near end crosstalk and far end crosstalk are measured at victim line. The sweep frequency range is 0 to 6 GHz.

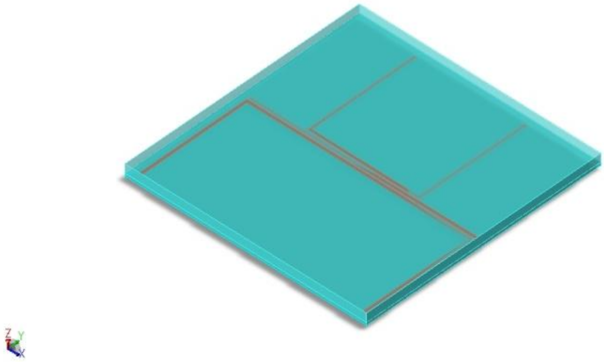
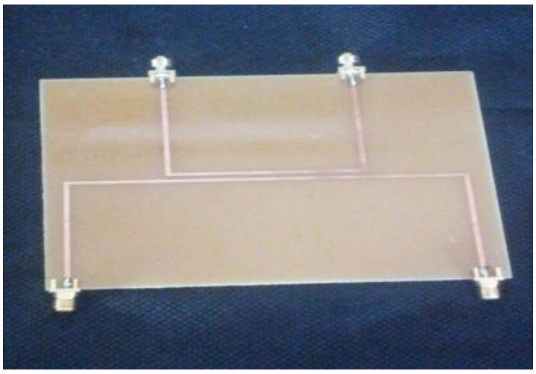


Fig.6. Simulated structure of the proposed microstrip configuration.

Fig.6. shows the simulated structure of the proposed microstrip configuration for multimodal analysis incorporated with ADS electromagnetic simulation tools.

B. ***Experimental Validation***

The photography of physical prototype testing structures constructed with the same parameters used in the simulations to test their experimental performance which is shown in Figure 7. These structures are modelled as 4 port networks and all these ports are terminated with 50 ohms. We have looked into our proposed model in the frequency domain up to 6 GHz. These structures are fabricated over FR4 substrate. The microstrip lines are terminated by 50 ohms impedance. All ports are 50 ohm resistor to make an approximate measurement. The effects of mitering is investigated in terms of near end crosstalk and far end crosstalk.



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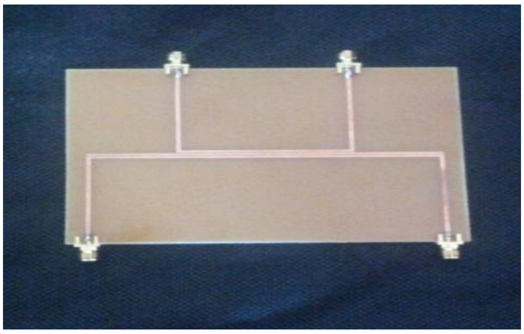

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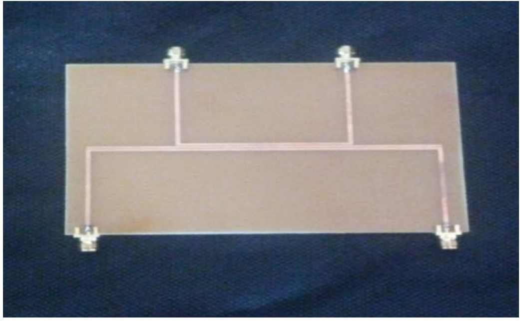
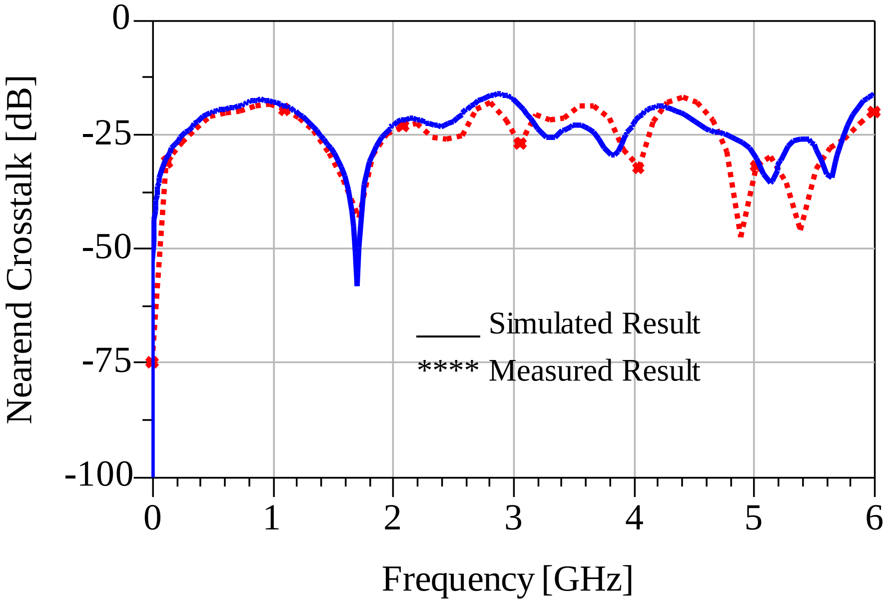


(c)

Figure 7: Photographs of (a) Coupled Microstrip Transition (b) Coupled Microstrip Transition with Mitered bend (c) With Guard Trace



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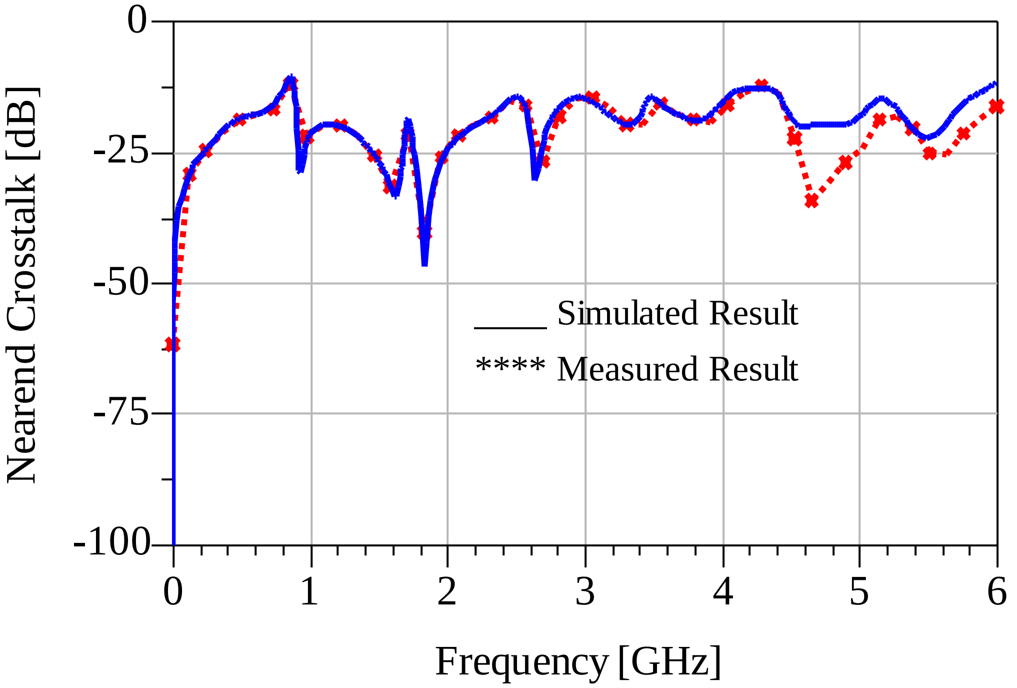

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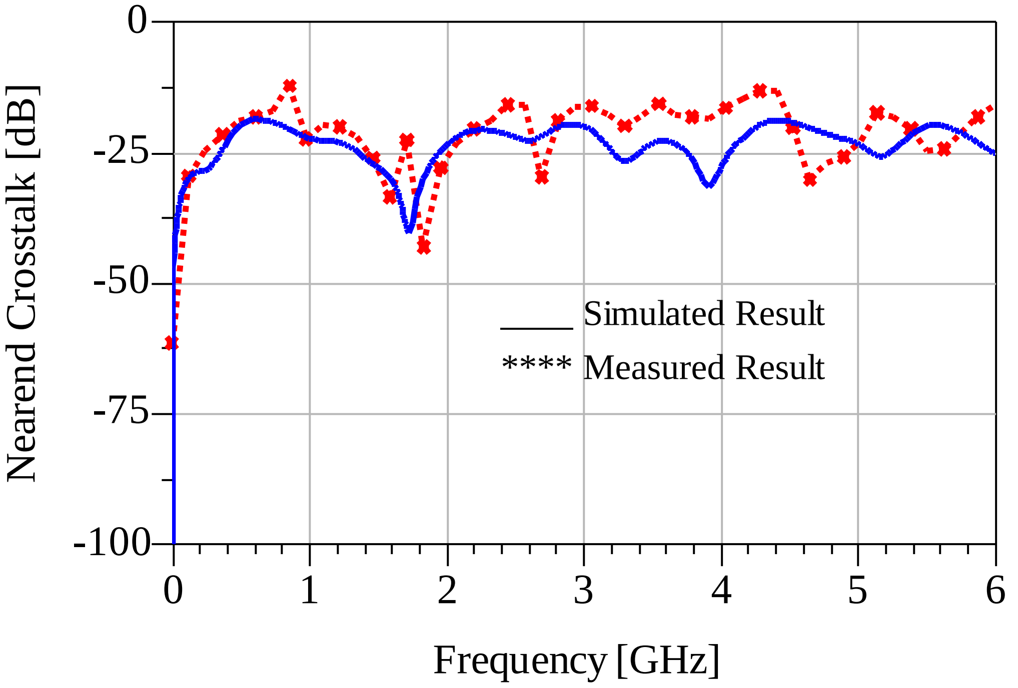
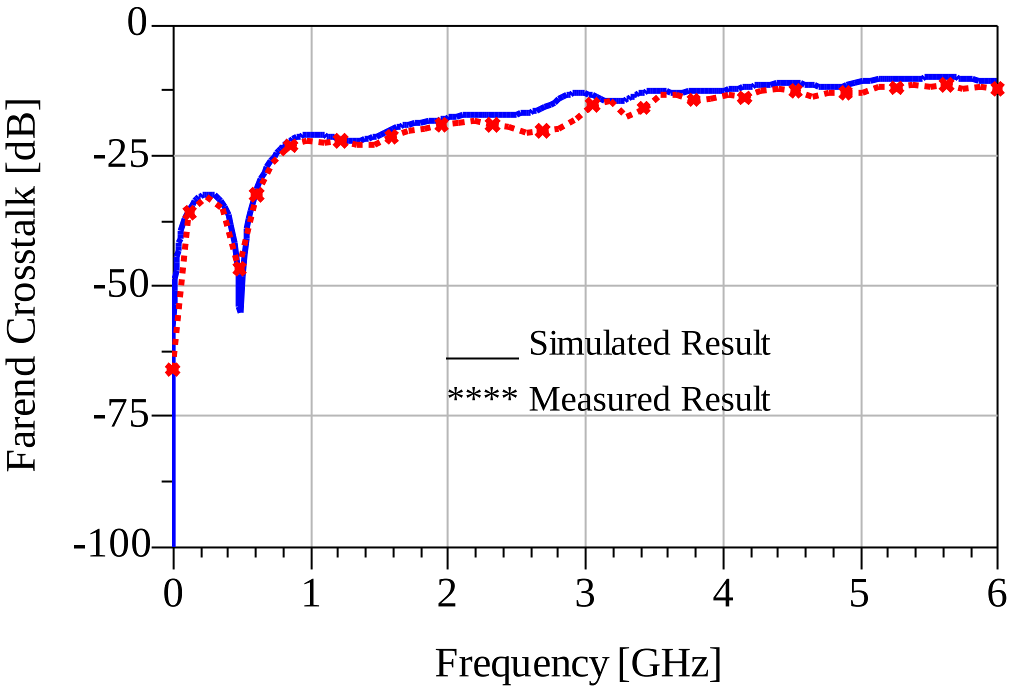


(c)

Figure 8: Simulated and measured NEXT of (a) Coupled Microstrip Transition (b) Three line coupled microstrip transition (c) Three line coupled microstrip transition with mitered bend(proposed)

Figure 8 shows the simulated and measured results of NEXT for various transition circuit models. In this figure solid line represents simulated results and dashed line represents measured results. From this we observed that near end crosstalk can be reduced more than 40% by our proposed mitered bend configuration.

Table 1 gives the comparison of crosstalk performance on various models. Coupled microstrip transition. It shows there is a good agreement between simulated and measured results.



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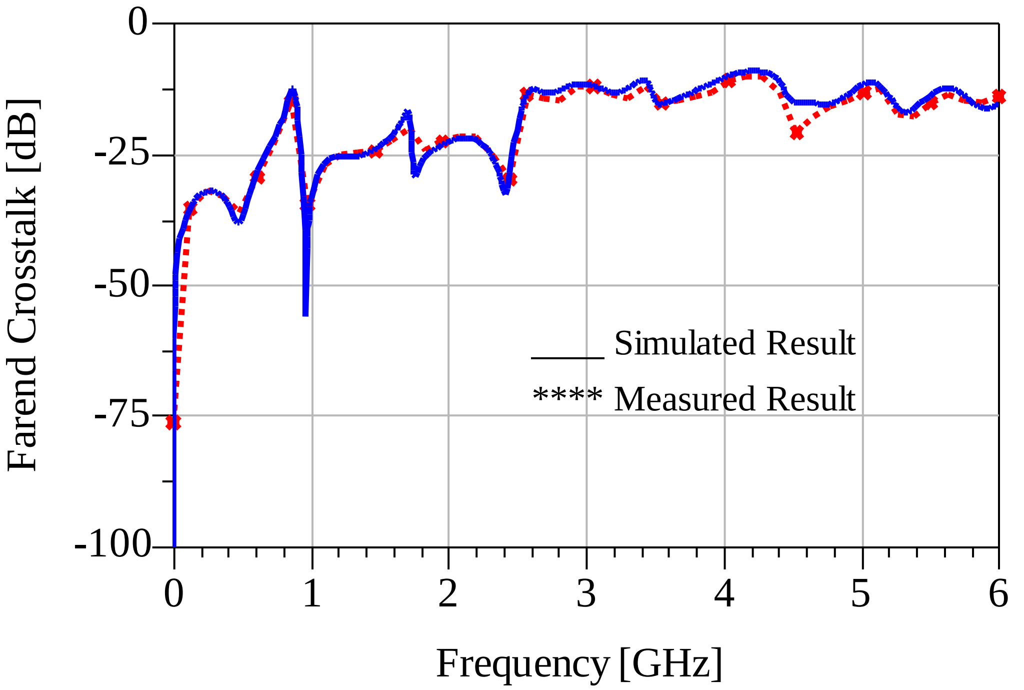

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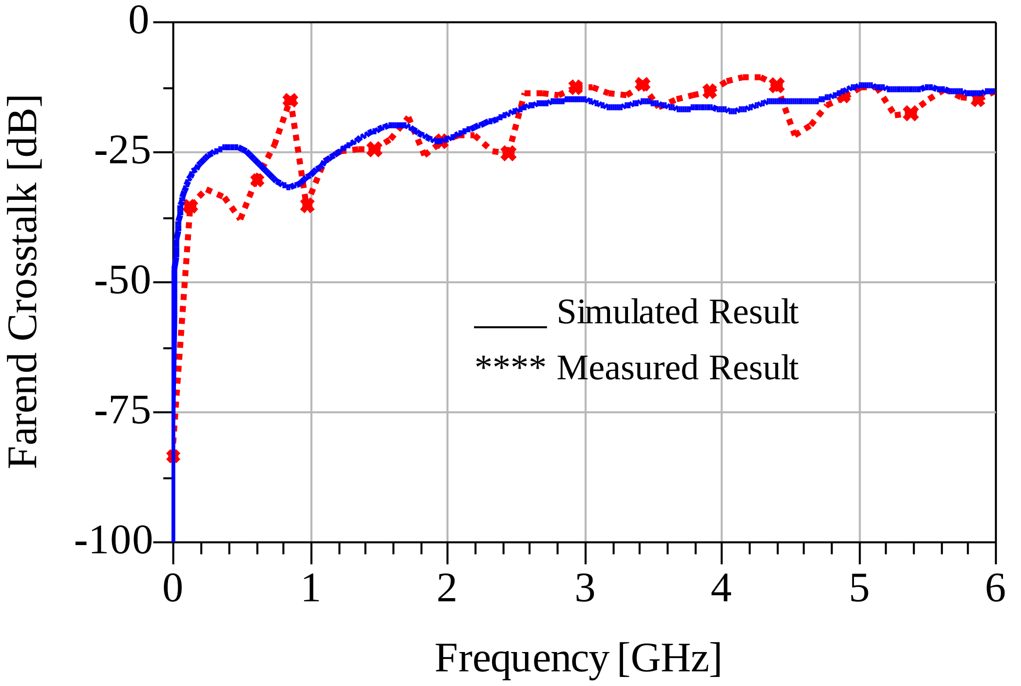

(c)

Figure 9: Simulated and measured FEXT of (a) (a) Coupled Microstrip Transition (b) Three line coupled microstrip transition (c) Three line coupled microstrip transition with mitered bend (proposed)

Table 1: Crosstalk for various models

Models	**Simulated**		**Measured**	
	NEXT (dB)	FEXT (dB)	NEXT (dB)	FEXT (dB)
Coupled Microstrip Transition	-16..201	-12.381	-18.204	-11.981
Three line –coupled microstrip Transition	-13.345	-11.132	-12.254	-11.092`
Proposed Model	-25.581	-14.381	-20.197	-13.381

Three line coupled microstrip transition introduces NEXT and FEXT than Coupled Microstrip Transition. Here, the results show that the insertion of guard trace in coupled microstrip transition increases more than 40% and 17% NEXT and FEXT respectively than coupled microstrip transition. Our proposed model performed well at reducing the NEXT by about 12dB and also reducing the FEXT by about 3dB.

The discrepancies with measured and simulated results for many reasons. They contributed by fabrication errors, not together with the consequences of thickness of conductors in simulation and frequency dependent nonconductor losses, instrumentality loss occur between the instrumentality and also the PCB. Our proposed model reduces NEXT and FEXT by 40% and 17%, respectively, more than conventional structures.

Conclusion

In this paper, the NEXT and FEXT of Three line Coupled Microstrip Transition on printed circuit boards were simulated with a frequency range up to 6 GHz. The results obtained from the ADS simulation tool were compared with the measured results. There was good agreement between the simulation and experimental results. The coupled microstrip transition with mitered bend reduced the FEXT by more than 40%, and also reduced the NEXT by more than 17%. For highly dense interconnects, the FEXT and NEXT must be reduced further, with a minimum fabrication space. Hence, novel routing topologies are required.

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