Final Project - Literature Review **NAMES**

ECEN-5224

Professors: Eric Bogatin and Melinda Piket-May Due Date: 03/16/2018

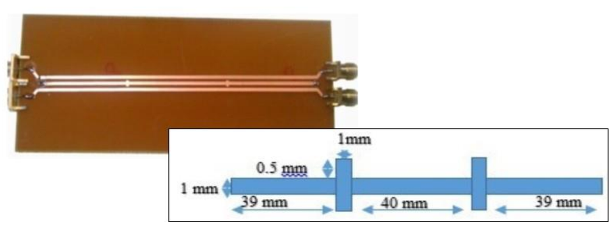
1 Problem Statement

Accordingly Bogatin [1], between every two nets in a system, there will always be some combination of capacitive coupling and inductive coupling arising from these fringe fields. We refer to the coupling capacitance and the coupling inductance as the mutual capacitance and the mutual inductance. (...) The far-end noise voltage is related to the net coupled current through the terminating resistor on the far end. This, after all, is the voltage that is propagating down the quiet line in the forward direction. (...) If there is any inhomogeneity in the distribution of dielectric materials, the fields will see a different effective dielectric constant depending on the specific voltage pattern between the signal lines and the return path, and there will be a difference in the relative capacitive and inductive coupling. This will result in far-end noise.

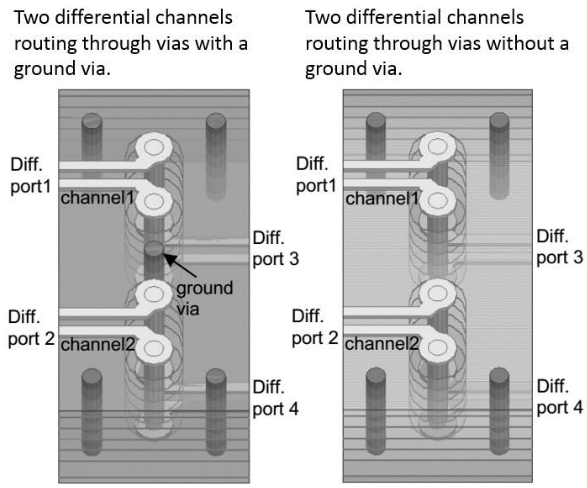
2 Literature Compilation

A brief review of investigations about reducing crosstalk effects is done in descending chronological sequence. The selected studies are concentrated in board-level approaches, i.e., the fields distribution in signal and return paths are modified by changing the geometry of traces.

In 2016, Tidjani [2] proposed a new approach for reducing parasites coupling between coupled transmission lines employed in power electronics is presented, based on adding tee guard line (TGL), between the coupled microstrip lines. The NEXT is reduced about 78% and the FEXT about 82%. Also the crosstalk peak is reduced by about 82%. S-parameters are analyzed but no time-domain response is presented.

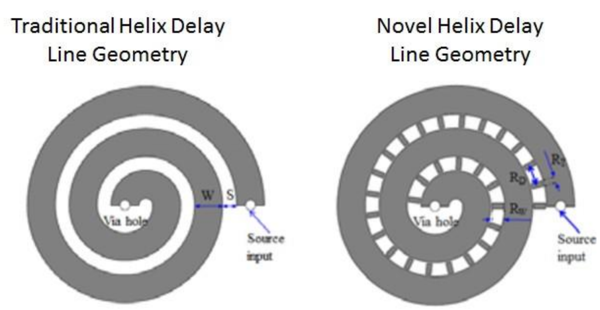


In 2014, Aihara [3] presents the design of electrical interconnect for high-speed data transmission involving differential signal vias on printed circuit board (PCB). Between two channels of differential vias, with given intra pair via pitch and spacing from adjacent channel vias, there exists an offset angle where differential crosstalk is minimized. By studying single-ended terms of NEXT and FEXT relation in both time and frequency domain, it becomes clear that such phenomenon occurs once in every quadrant. The crosstalk reduction can be achieved without placing ground vias in between signal vias of two channels, giving more routing space in high-speed PCB designs.

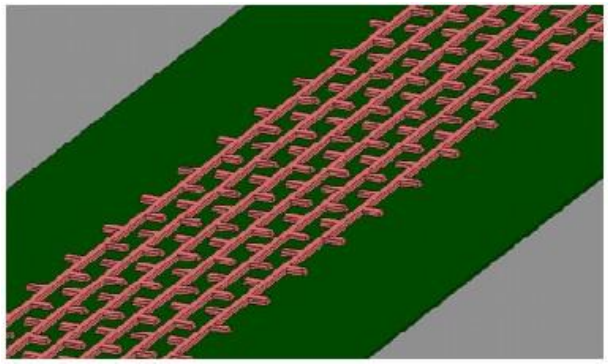


In 2015, Lin [4] proposes two novel structures for helix delay line. Delay lines are widely employed in high-speed circuit for delay time synchronization and timing skew minimization, popular schemes are serpentine and spiral routing. In order to reduce the manufacture cost and routing area, spacing between adjacent unit lines should be smaller, but it increases in electromagnetic coupling and crosstalk from adjacent lines.

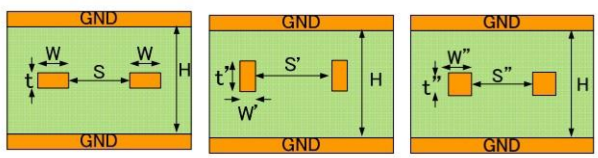
To this kind of solution, near-end crosstalk (NEXT) is a main noise that accumulates at the receiving end and results in waveform degradation of time-domain transmission (TDT). Although there are many strategies for crosstalk noise reduction, yet the crosstalk noise like NEXT always exists and may affect system-level timing and cause error switching of logic gates. Compared with conventional serpentine and spiral delay lines, the far-end crosstalk (FEXT) is a dominant noise that accumulates at the receiving end. Simulation results show that FEXT noise in the new purposed helix delay line structure can dramatically decrease 77.6 eye-opening and eye-jitter can improve 28% and 33.4% compared with traditional solution.



In 2013, Chhay [5] presented a geometry study so-called Stub-alternated lines (stubby lines), which intended to reduce or eliminate FEXT. Stubby microstrip wiring consists of short rectangular stubs added to the edges of the wire, orthogonal to the direction of propagation. These stubs effectively increase the mutual capacitance between the lines without significantly increasing the mutual inductance, and accordingly allow the designer to mitigate. The final difference between the mode velocities, together with the length of the stubby line section, determine the magnitude and polarity of the FEXT signal observed at the end of the line. The final geometry is shown below.

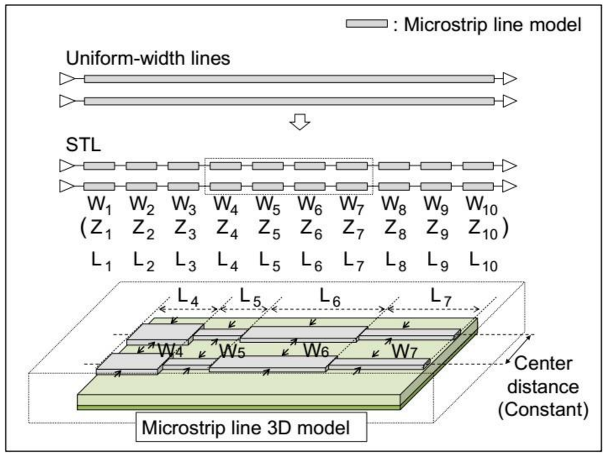


In 2015, Kuwahara [6] investigated the cross-sectional shape of the trace of printed circuit board, which can reduce the cross-talk interference or improve the wiring density. Three patterns of the cross-sectional shape of the trace are examined in this paper. The one is conventional rectangular shape, which the width of the trace is longer than the thickness (low aspect ratio), and the second pattern is a shape of high aspect ratio (the thickness of the trace is longer than the width), and the last trace pattern is a shape of square. The characteristic impedances of the all three trace patterns are designed to be 100 ohm in differential mode. Also, the cross sectional area is arranged to be same among the three trace patterns in order to make the transmission loss conditions are same. Results show the amount of cross talks becomes minimum when the cross sectional form of the trace is square. Simulations were performed by the HSPICE for circuit analysis HFSS for 3D electromagnetic-field analysis.

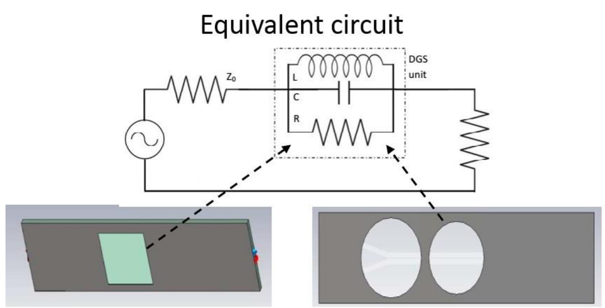


(a) Wide Rectangle (b) Thick Rectangle (c) Square (proposed)

In 2013, Seiki [7] brings an alternative solution to reduce crosstalk-noise instead of to widen space or to put shield trace between traces in PCBs through applying a new trace structure Segmental Transmission Line (STL) to reduce crosstalk-noises caused by random data signal in GHz domain and demonstrates that the STL can reduce the crosstalk-noise to about half of it in the uniform-width trace.



In 2012, Henridass [8] analyzes some defective ground planes (or structures DGS) to reduce space between traces through observation of crosstalk behavior. The basic element of DGS is a resonant gap or slot in the ground metal, placed directly under a transmission line and aligned for efficient coupling to the line. Each structure differs in occupied area, equivalent L-C ratio, coupling coefficient, higher order responses, and other electrical parameters.



Analyzed geometries of DGS'

Solutions to be Investigated & Work Methodology

The goal is to reduce FEXT (far-end crosstalk) by exploring different geometries of stubby lines simulated in a full-wave electromagnetic 3D simulation tool (HFSS). The investigation methodology is resumed in the following steps:

1. Pre-design of standard coupled lines for specific differential impedances using auxiliary Circuit CAD (ADS or GENESYS);
2. Perform full-wave simulations (HFSS), obtain S-Parameter matrix, and transfer it to ADS to analyze step response. Determine the minimum necessary bandwidth need to stabilize response in time domain;
3. Simulate tabbed lines in HFSS in different configurations (distance, distribution, width) and compared performance through step response and eye diagram (TDR - Time domain reflectometry tool)

Final Considerations

A literature review and approach outline for final project were presented. It's observed that ”Stubby Lines” seem to be a good alternative for reducing crosstalk since it is easy to build and can be explored under many geometrical variations.

References

[1] E. Bogatin, *Signal integrity: simplified*. Prentice Hall Professional Technical Reference, 2008.

[2] N. Tidjani, A. Ouchar, and J. C. L. Bunetel, “An approach for reducing parasites coupling between coupled transmission lines employed in power electronics,” in *Proc. Technologies of Information and Telecommunications (SETIT) 2016 7th Int. Conf. Sciences of Electronics*. IEEE, Dec. 2016, pp. 291–294.

[3] K. Aihara, J. Buan, A. Nagao, T. Takada, and C. C. Huang, “Minimizing differential crosstalk of vias for high-speed data transmission,” in *Proc. IEEE 23rd Conf. Electrical Performance of Electronic Packaging and Systems*, Oct. 2014, pp. 191–194.

[4] D. B. Lin, C. P. Huang, C. H. Lin, H. N. Ke, and W. S. Liu, “Using rectangular-patches (rps) to reduce far-end crosstalk noise and improve eye-diagrams on microstrip helix delay line,” in *Proc. IEEE Int. Symp. Electromagnetic Compatibility (EMC)*, Aug. 2015, pp. 612–615.

[5] S. K. Chhay, R. K. Kunze, and Y. Chu, “Crosstalk mitigation in dense microstrip wiring using stubby lines,” in *Proc. IEEE 22nd Conf. Electrical Performance of Electronic Packaging and Systems*, Oct. 2013, pp. 231–234.

[6] T. Kuwahara, Y. Akeboshi, and S. Saito, “A study of high-density differential transmission line of the package board based on crosstalk reduction,” in *Proc. Int. Conf. Electronics Packaging and iMAPS All Asia Conf. (ICEP-IAAC)*, Apr. 2015, pp. 878–881.

[7] K. Seki, K. Kanazawa, and M. Yasunaga, “Crosstalk-noise reduction in ghz domain using segmental transmission line,” in *Proc. IEEE Electrical Design of Advanced Packaging Systems Symp. (EDAPS)*, Dec. 2013, pp. 96–99.

[8] A. Henridass, M. Sindhadevi, N. Karthik, M. G. N. Alsath, R. R. Kumar, and K. Malathi, “Defective ground plane structure for broadband crosstalk reduction in pcbs,” in *Proc. Communication and Applications 2012 Int. Conf. Computing*, Feb. 2012, pp. 1–5.