# Far-End Crosstalk Design Guideline For Coplanar Coupled Microstriplines Leading To A Crosstalk Design-Space

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***Abstract*—When two independent microstriplines are placed close to each other, the impact of the coupling between them on their signal propagation characteristics should not be neglected. For example, the proximity of two microstriplines to each other will influence the amount of crosstalk between them. Crosstalk is a strong function of the risetime of the aggressor's signal, the coupling length between the two microstriplines, as well as the magnitude of the aggressor's signal. Good, practical design guidelines for mitigating the effects of crosstalk include increasing the edge-to-edge separation distance between the two microstriplines, as well as minimizing their coupling lengths. Although these design guidelines are well-known in the industry, it is of practical importance to provide choices of separation distance and coupling length values to the design engineer in order to not exceed a certain maximum crosstalk voltage requirement. By doing so, the design engineer is then provided with a great deal of flexibility when routing coupled microstriplines. This paper presents a general approach for extracting this kind of design information within this crosstalk design-space. The conductor width, *W*, that is considered in this paper is equal to 6mils, while the distance to the conductors' reference plane, *h*, is equal to 5mils, which leads to approximately $62\Omega$ isolated impedances for both microstriplines.**

## I. Introduction

It is sometimes necessary to place microstriplines close to each other on a densely routed printed circuit board. One such application might be a data bus application in which each microstripline carries one bit of information, for example. When two independent microstriplines are placed close to each other, the impact of the coupling between them on their signal propagation characteristics should not be neglected. When two microstriplines are coupled to each other, crosstalk between the two circuits can occur. In this case, the amount of crosstalk is a strong function of the risetime of the aggressor's signal, the coupling length between the two microstriplines, and the strength of the aggressor's signal.

Although it is well understood in the industry that increasing the separation distance between the two microstriplines, as well as decreasing their coupling length tends to mitigate the amount of crosstalk, it is of practical importance to provide the design engineer with many choices of pairs of separation distance and coupling length values that will not exceed a given maximum crosstalk voltage requirement. By doing so, the design engineer can then route the coupled microstriplines with a great deal of flexibility.

## II. Simulation Results

The extraction of the edge-to-edge separation distance and coupling length value design-space for a given microstripline geometry is accomplished by first determining the crosstalk voltage for a range of edge-to-edge separation distances and coupling lengths. For example, this range might be 4mils ≤ separation distance ≤ 24mils, and 1inch ≤ coupling length ≤ 11inches. In this case, the crosstalk voltage would then be plotted as function of these values and as a surface plot. Next, the maximum tolerable crosstalk voltage would then be superimposed onto this surface plot as a plane.

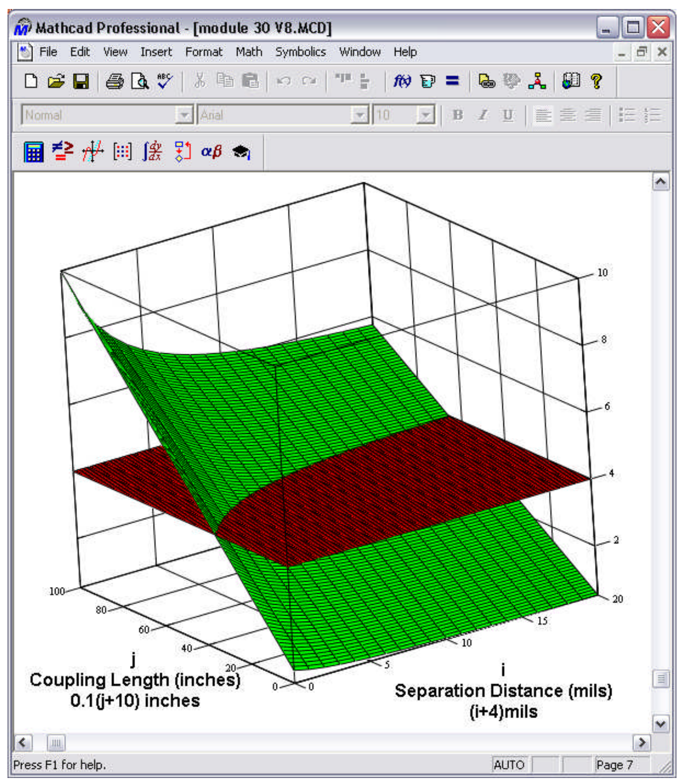


Fig. 1. Surface plot of the percentage crosstalk (green) and the percentage crosstalk limit (4%) shown as a red plane.

Figure 1 shows an example display of this kind of information, in which the maximum crosstalk voltage is 0.4V. A numerical model, derived by the author, was used to determine the crosstalk voltage. In this case, the crosstalk voltage is shown in green color and represents the expected percentage crosstalk when swept over the displayed pairings of edge-to-edge separation distances and coupling lengths. The conductor widths are 6mils, whereas the distance, *h*, to the reference plane for both microstriplines is 5mils, which leads to isolation impedances of about 62Ω. Isolation impedance, in this case, implies the impedance of an individual microstripline, and does not take into account any even and odd mode switching behaviour influences from the two coupled microstriplines on this intended impedance. The maximum voltage of the aggressor and susceptible signals is 1.0V, and the risetime of the aggressor's signal is 2ns.

The region below the red (0.4V) plane represents crosstalk voltages that are less than 0.4V. On the other hand, the region above the red plane represents crosstalk voltages that are greater than 0.4V. Finally, the intersection of the green and red surfaces represents a contour that highlights the infinite number of pairings of edge-to-edge separation distance and coupling length values that will lead to a maximum crosstalk voltage of 0.4V. When the surface plot is viewed from the top of the plot, then the surface plot becomes a planar surface, and is shown in Figure 2.

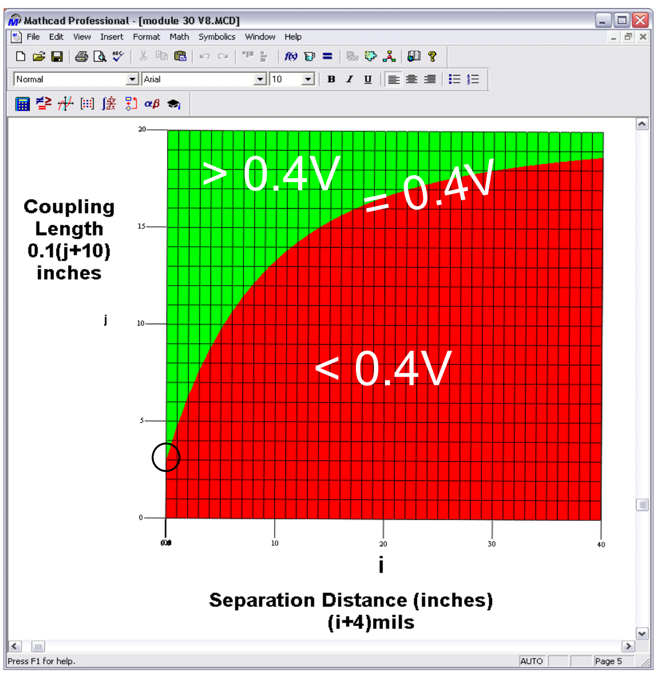


Fig. 2. Top view of the percentage crosstalk surface plot, and the resulting crosstalk design-space.

From Figure 2, the designer can readily extract the contour from the intersecting regions that leads to the infinite pairings of edge-to-edge separation distance and coupling length values that produce exactly 0.4V of crosstalk. For example, for a separation distance of 4mils, the coupling length should not exceed about 1.3inches. This operating point is shown as a black circle in Figure 2. As expected, as the edge-to-edge separation distance between the two microstrip lines increases in value, the allowable coupling length also increases in value. Plots such as Figure 2 can highlight a great deal of design options to the design engineer who is routing the signals. For the sake of completion, Figures 3 and 4 highlight the design-space information for 0.3V and 0.2V maximum crosstalk voltages, respectively.

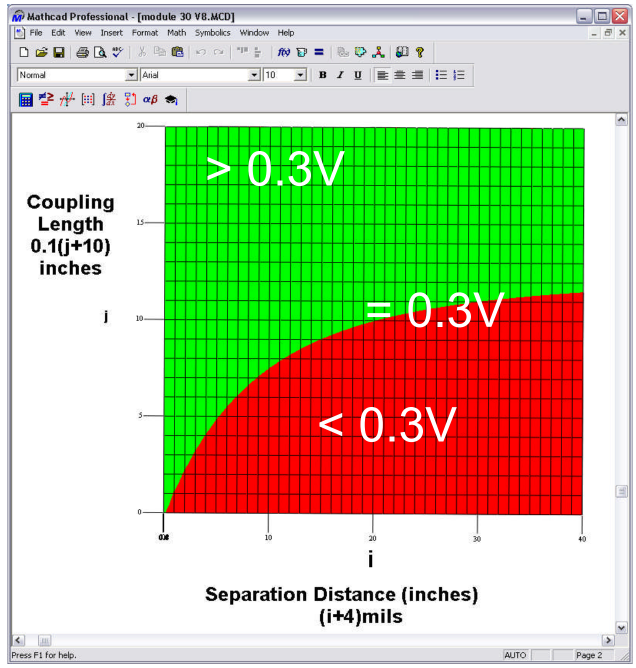


Fig. 3. Crosstalk design-space for a 0.3V crosstalk voltage requirement.

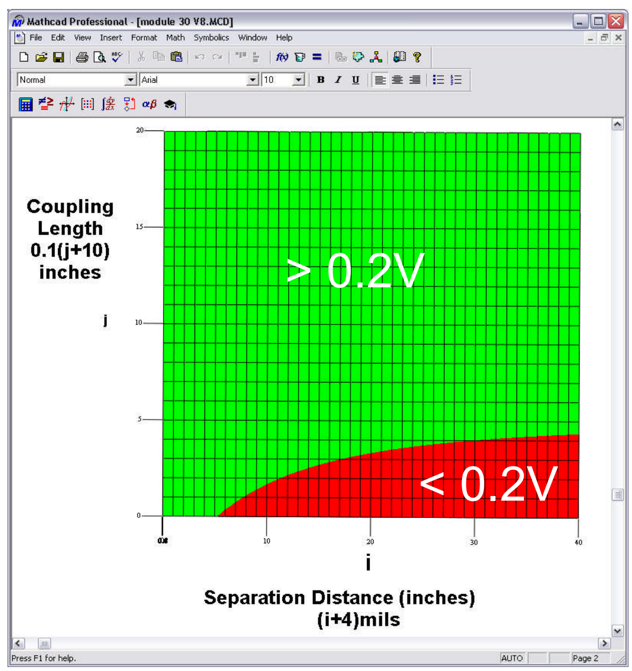


Fig. 4. Crosstalk design-space for a 0.2V crosstalk requirement with a 2ns risetime.

Figure 5 shows the crosstalk design-space for the case in which only the risetime of the aggressor's signal has increased from 2ns to 3ns, and in which the maximum crosstalk voltage is 0.2V. In this case, the red colored design-space for this 3ns risetime scenario is larger than the associated design-space for a 2ns risetime, as expected.

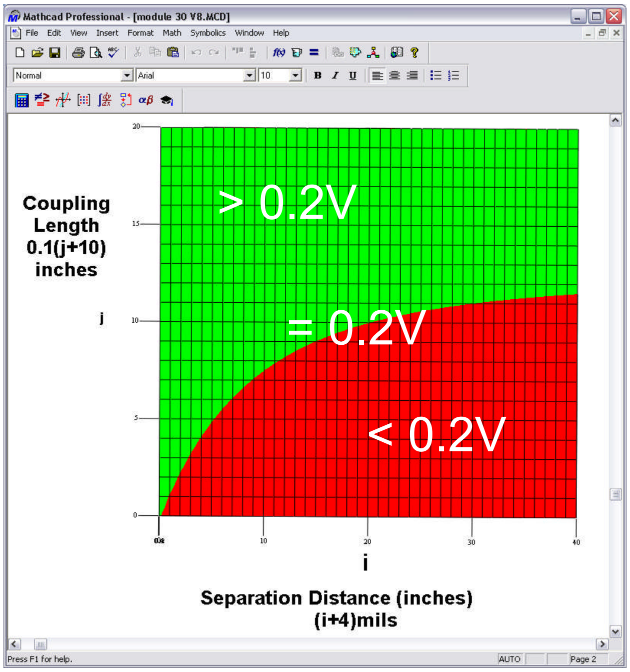


Fig. 5. Crosstalk design-space for a 0.2V maximum crosstalk voltage when only the risetime of the aggressor signal is increased from 2ns to 3ns.

## III. Conclusions

Based upon the previous research, it was disclosed that presenting the crosstalk voltage between two coupled microstriplines as a colored surface plot, over a specified range of edge-to-edge separation distances and coupling lengths, led to a crosstalk design-space when superimposed with the required maximum crosstalk voltage represented as a different colored plane. The intersection of these two surfaces led to a contour that defined an infinite number of pairings of edge-to-edge separation distances and coupling lengths that exactly produced the maximum tolerable crosstalk voltage. The planar region defined by the crosstalk voltage that is less than or equal to the maximum tolerable crosstalk voltage defines the crosstalk design-space.