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Invited

General Understand to Reduce the Cross-Talk between Digital Signal Line

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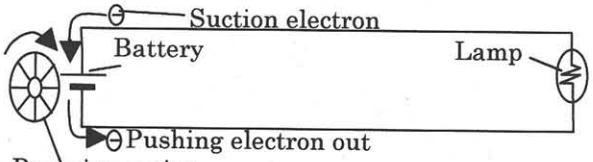
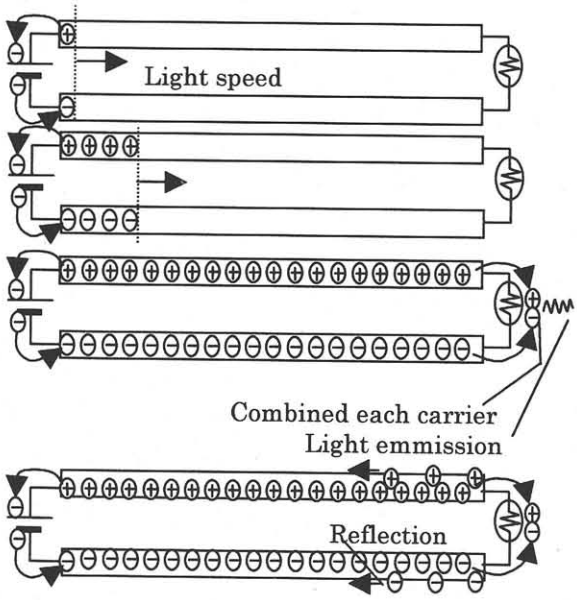
1. Propagation of signal energy on lines

Home power electricity or telephone cables are set of two lines that are named couple lines. You could not define which is ground line in these couple lines. Digital circuits have made us the sense of feature in one signal line and ground plane. Then you often forgot the ground that should be paired with signal lines. The principle is explained as flowing Figure 1.



(a) First action when battery connection



(b) Carrier act along transmission line

Figure 1 Principle of carrier energy transmission

The battery supplied the electrons from the cathode, but it can not create the electrons itself. Battery must correct the same number of electron from the anode simultaneously. This function is only pumping action for the electrons from anode to cathode. The line of anode side makes lack of electrons that means holes with plus charge. The line of cathode side is pushing electrons out. Then the two couple lines do flow the +/- paired charge from the battery to the right hand side. The flowing signal speed (not electron or hole speed) is the light speed named time-of-flight as you know. If you can imagine the bottom line is ground, but this line is minus level after charging that means swing at on/off actions. The battery only feels resistance of the couple lines at first. If the load is high resistance, the signal energy (charge quantity) is larger than consumption of the load, signal energy does then reflect at the site.

2. Electromagnetic field of transmission line

Couple line as like Figure 1 is a transmission line, which makes electromagnetic field at signal energy propagation. Several transmission lines are shown in Figure 2, which you can easy understand to be more spreading field in microstrip line on Figure 2(a) and most shrinking field in stacked pair line in Figure 2(d) at the same insulating thickness of Figure 2(a). One noticed thing is higher frequency makes the microstrip line to closer electromagnetic field (shorten length of "s" at image conductor) as Figure (b). A question generates how to relate "s" and frequency that will be presented on site. Naturally said, spreading field does much interfere with other field as neighbor transmission lines. Shrinking the field is the most important to reduce the cross talks simply. Therefore, we would find the strong coupling on

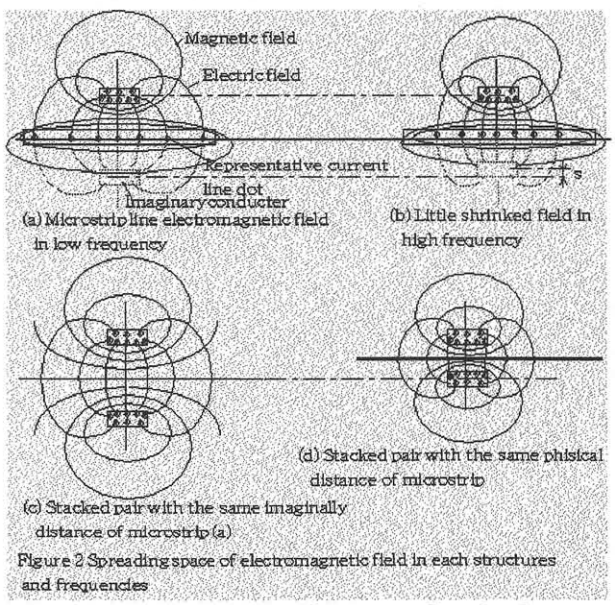


Figure 2 Spreading space of electromagnetic field in each structures and frequencies

the transmission line as shown in Figure 2 (d). This means lower characteristic impedance as like the RAMBUS protocol at 38 ohms than standard 50 ohms of microwave field. Anyhow, which is better transmission line, microstrip feature or stacked pair feature. An experimental evidence will be discussed as follows.

3. Reducing cross-talk feature on experimental basis

The pattern of measurement coupons made build-up FR-4 board with 200mm length of 9 parallel lines. The insulating thickness was 0.06mm and the space between neighbor lines was 0.2mm. To match 50 Ω characteristic impedance, line width was designed with 0.18mm on the stacked pair feature and 0.11mm on microstrip line feature. Open terminations were applied at the far end of measurement sites. The 100% of reflections were made in each, that meant more severe in neighbor transmission lines on the cross talks. Figure 3 is one of far end measurement example of signal wave forms with less than 1ns rise time that could understand having ability above 350MHz pulse transmission. The ratio of peek-to-peek swings / receiving signal swing meant cross talk noise intensity at the neighbors were round up on the Table 1. This was the result with little bit lower cross talks at the stacked pair line than that of microstrip line.

Simple important result, but seldom recognition was clarified here. Over 350 MHz digital signals, defined return line must be designed as like stacked pair line. Micro strip line with plane structure has not been made sense as return line. Then often designers have made slits or holes on the plane along the signal lines that lose return paths. While stacked pair line is easy to define the return line even better in cross talks. We therefore must think more in concept of paired structure and electromagnetic field spreading at high frequency (several hundreds MHz) digital circuit design, especially in packaging design field. If the frequency over GHz order will be designed, chip wiring should be considered by this concept as well.

Table 1 Measurement cross talk as out put ratio

Line feature	Neighbor line	Two lines neighbor
Microstrip	12%	4.4%
Stacked pair	8.8%	3.8%

Presentation will be done more in detail with many additional data.

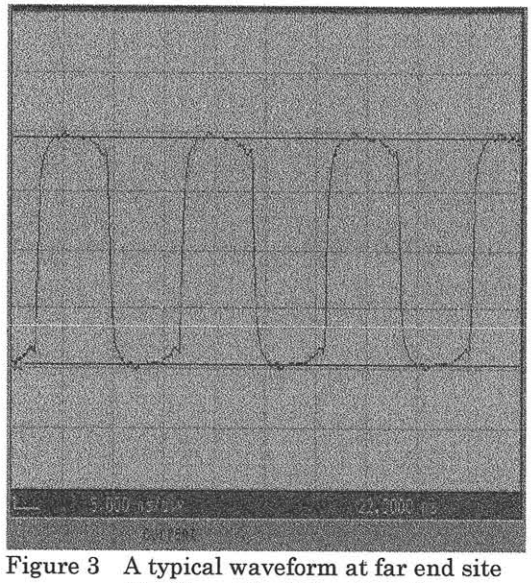


Figure 3 A typical waveform at far end site (5ns/div., 10mV/div., less than 1ns at rise and fall time)