University of Colorado - Boulder

ECEN 5730
Practical PCB Design Manufacture — Fall 2024

Lab 9 Report - Measuring Cross Talk Between Signal-Return Loops

Sam Walker Samuel Walker

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College of Engineering & Applied Science
UNIVERSITY OF COLORADO BOULDER

Introduction

In this lab, we will investigate cross talk between signal-return loops using a custom-designed PCB with multiple return paths. Cross talk is an important factor in PCB design, particularly in systems with high-speed signals. It can cause signal degradation and noise that affect performance. The aim of this lab is to measure and analyze the cross talk between aggressor and victim lines on a PCB, focusing on the impact of different return paths and ground planes.

The purpose of this lab is to:

- Measure the cross talk with a continuous return plane and compare it to a setup without a ground plane.
- Explore the effects of using common and separate return paths for signal loops.
- Analyze how the positioning of components and signal traces impacts cross talk.
- Develop a deeper understanding of best PCB design practices to mitigate cross talk.

Circuit Design

The PCB used in this experiment includes signal and return traces arranged to measure the cross talk between them. The aggressor signal is generated by an Arduino pin, and the victim signal is measured at different points on the board. Two configurations are tested: one with a continuous ground plane and one without.

The testing setup of the PCB with the ground plane is shown below:

Figure 1: PCB Testing Setup with Ground Plane

We also tested the PCB without a ground plane to observe how the absence of a continuous return path affects the cross talk.

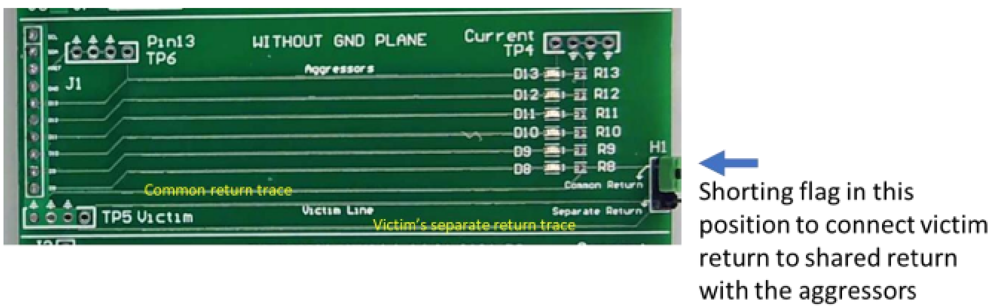

Figure 2: PCB Testing Setup without Ground Plane

Results

Trigger Signal

The waveform used to trigger the rest of the measurements is shown below. This signal is crucial as it serves as the reference for measuring the cross talk at various points on the victim trace.

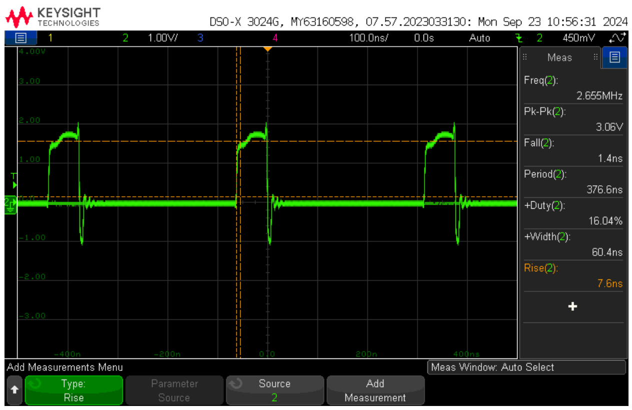

Figure 3: Triggering Signal

As shown, the amplitude is approximately 2V, with a pulse width of 60.4ns, a duty cycle of 16%, a rise time of 7.6ns, and a fall time of 1.4ns.

Switching Noise with Ground Plane

The next figures illustrate the switching noise observed on the victim line when the ground plane is in place. The noise is approximately 500mV peak to peak, and this signal will serve as the reference for the remainder of the tests.

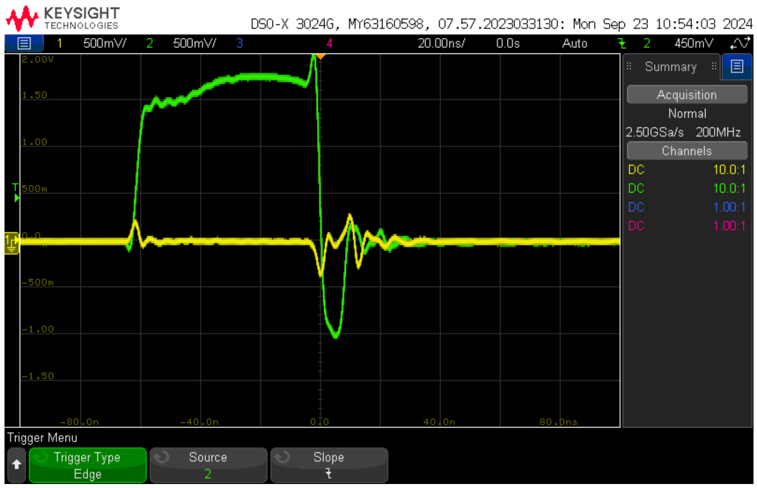

Figure 4: Switching Noise with Ground Plane

Switching Noise Comparison - Pins 13 and 8

The noise generated by pin 13 alone is compared to the noise generated by both pin 13 and pin 8 combined. As expected, the noise is significantly higher when both pins are active due to their proximity to the victim loop.

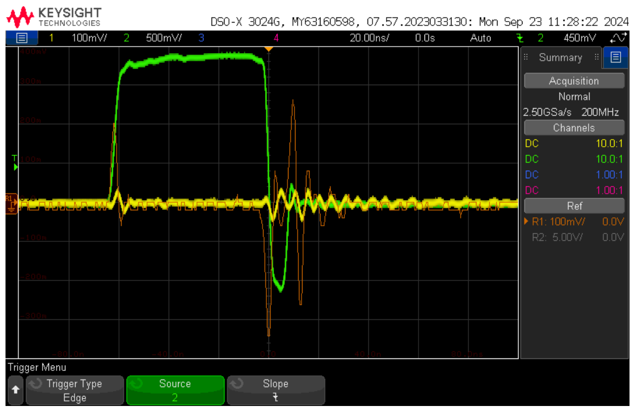

Figure 5: Noise from Pin 13 Only

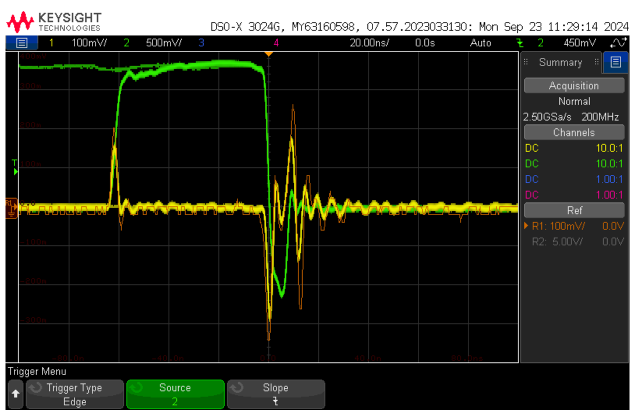

Figure 6: Noise from Pins 13 and 8

The noise generated by pin 13 alone is compared to the noise generated by both pin 13 and pin 8 combined. With the ground plane in place, pin 8 shows more noise than pin 13. This is because pin 8 is physically closer to the victim loop, resulting in stronger coupling and more interference, even with the presence of a ground plane providing a low-impedance return path.

Switching Noise without Ground Plane

The following figures compare the cross talk with common and separate return paths. With a common return path, the peak-to-peak noise reaches up to 4V, while with separate return paths, the noise maxes out at only 1V. Both signals are significantly worse than with the ground plane, which only exhibited 500mV peak-to-peak noise.

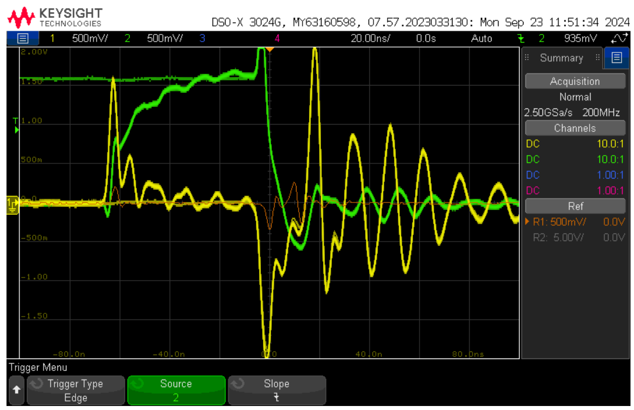

Figure 7: Switching Noise with Common Return Path

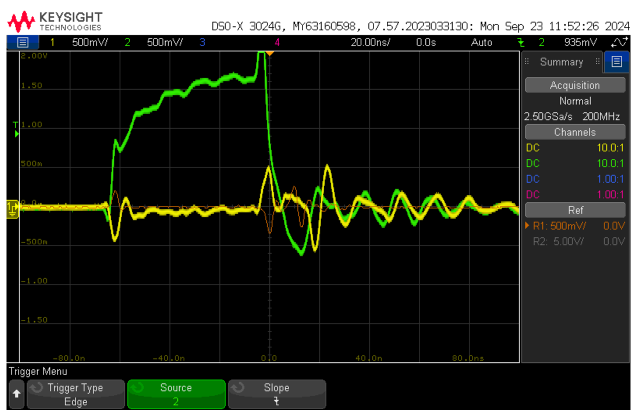

Figure 8: Switching Noise with Separate Return Path

Pin 13 and Pin 8 Noise without Ground Plane

The following figures illustrate the noise from pin 13 and pin 8 individually when no ground plane is used. The measurements are triggered differently for each pin to isolate their effects.

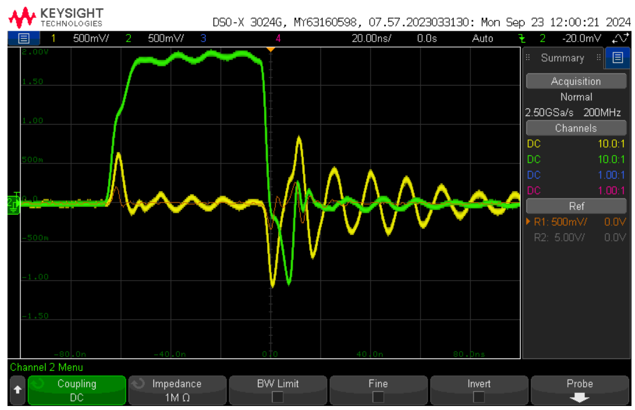

Figure 9: Noise from Pin 13 Only with No Ground Plane

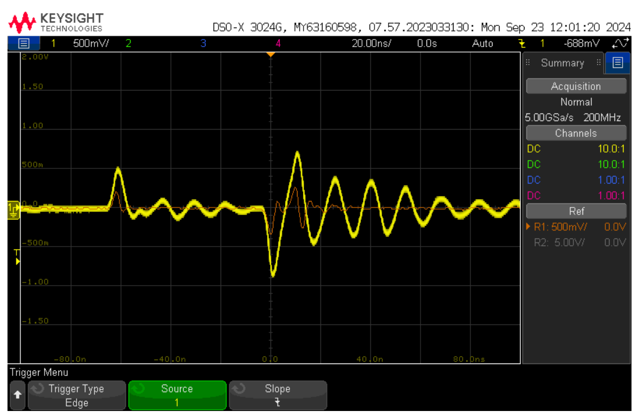

Figure 10: Noise from Pin 8 Only with No Ground Plane

Without a ground plane, the return paths are less well-defined, and both pins 13 and 8 generate similar noise levels. In this case, the absence of a continuous ground return makes the system more susceptible to interference, reducing the impact of proximity and causing the noise on both pins to equalize

Conclusion

This lab demonstrated the impact of cross talk between signal-return loops under different conditions. The key takeaways include:

- A continuous ground plane significantly reduces cross talk, with the noise level being as low as 500mV peak-to-peak.
- Using separate return paths mitigates cross talk more effectively than a common return path, reducing the noise to around 1V compared to 4V.
- The proximity of components and traces plays a critical role in determining the level of cross talk, particularly in the absence of a ground plane.
- For high-speed PCB designs, ensuring proper return paths and minimizing the loop area are essential to reduce interference and improve signal integrity.