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9-22-2024

ECEN 5730

Lab 9 report

**Introduction:**

In this lab the effects of switching noise were explored. When signals change their level of voltage and therefore usually their current in a circuit, there is a secondary effect on other signals in said circuit. Since moving charge generates a magnetic field, and a changing magnetic field induces a voltage in conductor loops, when more current is present in a circuit due to switching, the magnetic field generated by the circuit also changes and momentarily induces a noise in other signals.

**Equipment used:**

1xarduino

1x custom noise test PCB

1xBench oscilloscope

2xoscilloscope probes

1xwork laptop running Arduino IDE.

**General methodology:**

To demonstrate the effect of distance and current draw on the signal noise of a victim line, an Arduino was programmed to output digital signals on its GPIO lines in three different modes:

1. All signals on for approximately four clock cycles, then all off for one clock cycle
2. Each clock cycle a new signal turns on, until eventually all signals are on, then turn off for one clock cycle
3. All signals are cycled through individually per clock cycle, then when all signals have been activated once, turn off for one clock cycle.

The power return path of each of these signals are routed in decreasing order on the board, with pins of higher numerical value being closer to the test victim line on the PCB. These three different behaviors were tested in three different board configurations:

1. A PCB with a continuous return plane, i.e. copper fill covering the entire board
2. A PCB with separate return traces to the ground terminal
3. A PCB with separate return traces, with some shared return traces

**Code used:**

A screenshot of a computer code

Description automatically generated

(Simultaneous switching code)

A screenshot of a computer code

Description automatically generated

(sequential switching code)

A screenshot of a computer code

Description automatically generated

(Line alternation code)

1. **Continuous return plane**

A screen shot of a graph

Description automatically generated

(All on mode)

Here you can see that when all of the pins are active at once, there is significant noise on the victim line(green). A Possible remedy to this is to space out signal switching whenever possible when designing PCBS.

A screen shot of a graph

Description automatically generated

(alternating signals)

Here it can be seen that the noise is slowly increasing throughout the duration of this scope capture, this is because activated signals are getting physically closer to the victim line and therefore are inducing more noise in the circuit.

A screen shot of a graph

Description automatically generated

(sequential signals)

1. **Separate return trace that is not shared**

A screen shot of a graph

Description automatically generated(noise with all pins on)

Here it can be noticed that the voltage scale on the yellow victim line, is much higher than it is with the same experiment using a continuous return plane. Here it is 1 volt per division whereas in the previous example it was 200mV per division. The noise when using a continuous return plane is reduced significantly, as opposed to when using separate return traces.

A screen shot of a computer

Description automatically generated

(noise with sequential pin activation)

A screen shot of a graph

Description automatically generated

(noise with alternating active pins)

**3. Separate return trace is a shared return trace.**

A screen shot of a graph

Description automatically generated

(noise with all on behavior)

It can be seen here that there is more noise in the circuit by using a shared return path. This type of noise is called ground bounce, and is the result of multiple signals passing through the shared inductance of a common ground.

A screen shot of a graph

Description automatically generated

(noise with sequential switching)

A screen shot of a graph

Description automatically generated

(noise with pin alternating active pin)

**Conclusion:**

This lab demonstrates the impact that switching noise can have on signals through mutual induction. Continuous ground planes are used to reduce signal noise such as cross talk and ground bounce. Moreover, the importance of spacing out signals whenever possible, both in terms of activation time and spatial distribution was highlighted by the sequential and simultaneous signal experiments.