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ECEN 5730

Lab 5 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.

Moreover, the remedy to switching noise, decoupling capacitors, was introduced. Capacitors can be added to a circuit to supply current on a signal when the signal experiences noise. This added current can level out any voltage fluctuation and works more efficiently with capacitors with higher levels of capacitance.

**Equipment used:**

1xirf520 mosfet transistor   
1x10Ω resistor  
1x1000uf capacitor  
1x1uf capacitor  
1x100uf capacitor  
1xthree terminal switch  
1xarduino  
1xTLC272 Operational Amplifier

1xBench oscilloscope  
2xoscilloscope probes  
1xwork laptop running Arduino IDE.

**General methodology:**

The circuit below was constructed. An Arduino running code to pulse pin 13 with a frequency of 50hz. The signal oscillates at such a frequency so that the wattage of the resistor is not exceeded, as it is only a 1/4th watt resistor, and the Arduino is capable of outputting a much higher wattage. To test the impact of decoupling capacitors, pin 13 was connected to the gate of the transistor which’s source and drain are connected to a 9v powerline. The noise on the powerline is measured while the transistor switches on and off. To demonstrate the effect of faster rise times, an op amp was connected to p13, with a three terminal switch connected to the inverting and non-inverting terminals of the op amp. The gate was connected to the third terminal of the switch, so that either a slower op amp output signal or a faster Arduino signal can be tested. Faster rise times on signals can give rise to more signal noise, which is something that was tested and verified in this lab.

A circuit board with wires and wires

Description automatically generated

(circuit used in this lab )

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(model of circuit used in lab.)

**A screenshot of a computer code

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(code used in this lab)

**Decoupling capacitors**

Decoupling capacitors can be added to circuits to reduce the amount of noise on a signal line. In addition, by moving the capacitor closer to the circuit in question, this effect is amplified. This is because by being closer, the conductor length is shortened, and therefore the path from the power source to the ground line. This reduces the mutual inductance in the signal line.

To demonstrate this, the voltage on the resistor was measured(yellow) along with the voltage supplying the mosfet transistor(green). When the current flow in the circuit changed due to the gate of the transistor being set high, there is a noticeable amount of noise on the power line. When a 100 uf capacitor is added to the powerline, it can be observed that the amount of noise in the circuit decreases. This effect is far more noticeable when a capacitor of 1000uf is added to the circuit, as seen below.

A screen with a graph on it

Description automatically generated

(switching noise before adding 100 uf capacitor)

A screen with a graph on it

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(switching noise after adding in 100 uf capacitor)

A screen with a line drawn on it

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(Switching noise after adding 1uf capacitor)

A screen with a yellow line on it

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(switching noise after adding in 100uf capacitor)

**b. What is the loop inductance of the power path from the collector to the VRM? c. Show your measured values and how you made these estimates.**

**Thevenin equivalent circuit**

Vth was found by measuring the voltage supplied by the power supply, which upon being measured it was found to be exactly what was programmed into the supply. From this it can be concluded that when the supply is set to 9 volts, vth is equal to 9 volts.

In order to estimate the value of rth, a 1kΩ resistor was added to the 9v powerline(supplied by a bench dc voltage source), which in effect creates the following circuit.

A drawing of a rectangular object with lines and writing

Description automatically generated with medium confidence

The value of rth can be estimated via the following formula, and associated math:

A diagram of a circuit

Description automatically generated

With said math, it was found that the dc power supply had a internal resistance of approximately 5Ω.

**Conclusion:**

This lab demonstrates the importance of keeping decoupling capacitors close to their respective signals, along with the impact that fast rise times can have on circuit noise. Moreover, this lab encourages one to think about the impact of mutual induction in a circuit, and to design with non ideal models of circuits in mind.