Lab 5 Report: SBB PDN and slammer circuit

Name: Pradyumna Gudluru, Date: 2/19/2023

Purpose:

The purpose of the lab is to build a slammer circuit which will draw a fast transient current from the power rail.

1. To build a circuit demonstrating the origin of switching noise in the power path and the role of loop inductance.

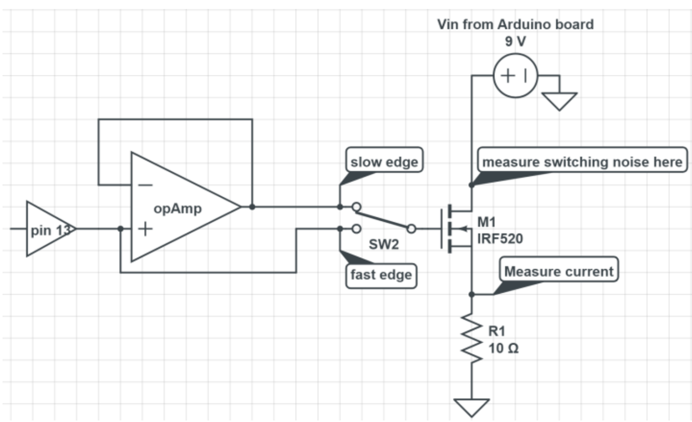
2. To measure the switching noise on the power rail when there is a large current transient.

3. To explore the role of loop inductance between the IC and the decoupling capacitors.

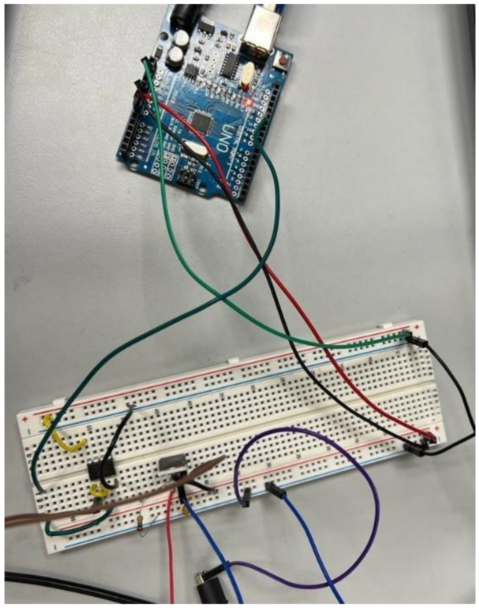
4. To see the difference in switching noise for different dI/dt values of current transient.

5. To estimate how much capacitance is needed to provide adequate local charge storage.

As per the manual, the slammer circuit to be built is given by, (Without any decoupling capacitors)



As per the above circuit with adding a decoupling capacitor the circuit looks like the following,



The Arduino Uno is connected to the system with the functioning code, with the Pin 13 to blink.

```
void setup() {
pinMode(13, OUTPUT);
}
void loop() {
digitalWrite(13, HIGH);
delay(1);
digitalWrite(13, LOW);
delay(20);
}
```

1. **Fast Pulse Input with & without decoupling capacitor:**

   The noise can be observed without adding the decoupling capacitor like below,

From the above image we can understand that, the high value induces a very high noise and voltage drop, but when connected a 1uF capacitor, the voltage drop is consistently decreased as below.

One observation here is that the capacitor tries to compensate the effect of inductance by providing charge storage.

2. **Slow Pulse Input with decoupling capacitor:**

With the slow rise time op-amp added in between the transmission, the voltage drop is minimal and the dI/dt value is decreasing as per the below screenshot.

3. **Working with 2 capacitors:**

With respect to 1uF and 22uF when connected, there is a lot of difference in the noise obtained. The value of the capacitance is directly proportional to the noise obtained, and the distance from the IC where the capacitance is placed plays a major role. If the decoupling capacitance is far from the IC then the noise is higher, when compared with decoupling capacitor planted near to the IC. The below image shows the difference in noise when the 1uF is placed near and far to the IC.

1uF Placed near to the IC

1uF placed far from the IC

4. **Calculation of Thevenin voltage and resistance:**
   $\mathbf{R_{th} = ((V_{th} - V_L)/V_L)*R_L}$
   The Thevenin voltage is measured 9V and the voltage is measured across 1k with voltage measured as 8.64V.
   Hence Rth = ((9-8.64)/8.64)*1k = 41.67 ohm.

5. **Loop Inductance:**

$\mathbf{\Delta V = L * dI/dt}$

Voltage drop observed is approximately 7.6V, and the change is current is V/R, approximately 436mA. The rise time visible was 20ns according to the fast pulse input.

Hence, Loop Inductance = (7.6 * 20ns)/0.436 = 348.62 approximately 350nH.

Conclusion/ Observations:

- The closer the decoupling capacitor to the IC, the lesser the loop inductance and lesser the noise.
- With the increase in value of capacitance, there is a decrease in the noise.
- The higher the input rate, the higher the voltage drop and noise, but lesser the rise time.