Board 2 - Haley Basti

Thursday, October 23, 2025 3:43 PM

Project Overview

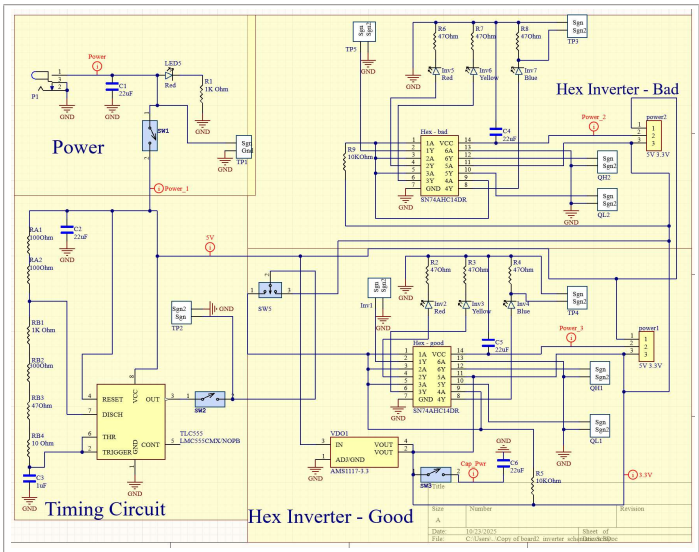
The purpose of this board was to show the differences in using best practices when designing a circuit (shorter power traces, continuous ground plane) using a 555 timer 500 Hz, 50% duty cycle output to two different hex inverter Ics, one made with best practices, and one without. The "Quiet Low" or input voltage and "Quiet High" ground inputs to the inverters were measured for their resulting noise.

POR: What it means to "work"

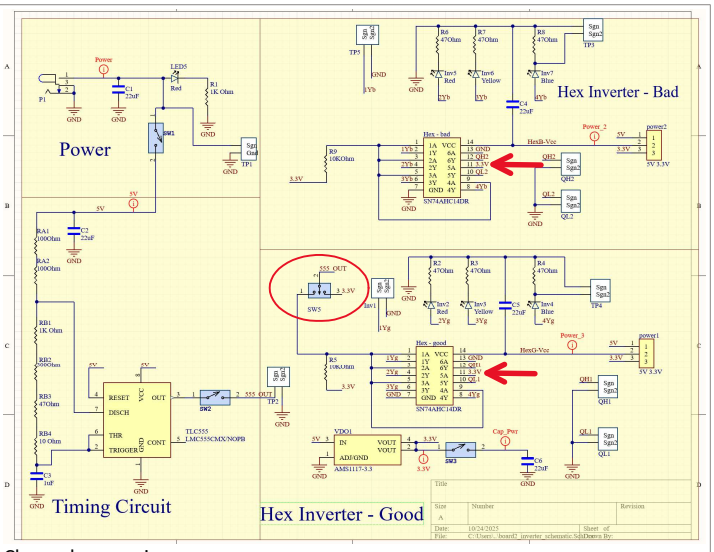
- 555 outputs 500 Hz, 50% duty cycle signal
- Inverters are shown to properly invert signal, with 3.3V and 5V on Vcc
- LEDs turn on, measurement across resistors allows me to calculate current through the resistors
- Quiet High and Quiet Low measurements on "Good" inverter show less noise than the "Bad" inverter
- Show effects of adding a decoupling capacitor to LDO

Unfortunately, I didn't use net labels in my original design, as seen below.
Due to this messy layout, I made an incorrect connection to switch 5, which was supposed to toggle the output of the 555 timer between the two hex inverters. After the schematic was cleaned up, I realized I had mistakenly put 3.3 V to the other side of the switch, instead of to the input of the "bad" hex inverter.

I also should have had the Quiet Low input on pin 11 toggled from the Vcc input, but instead it always sits at 3.3V.

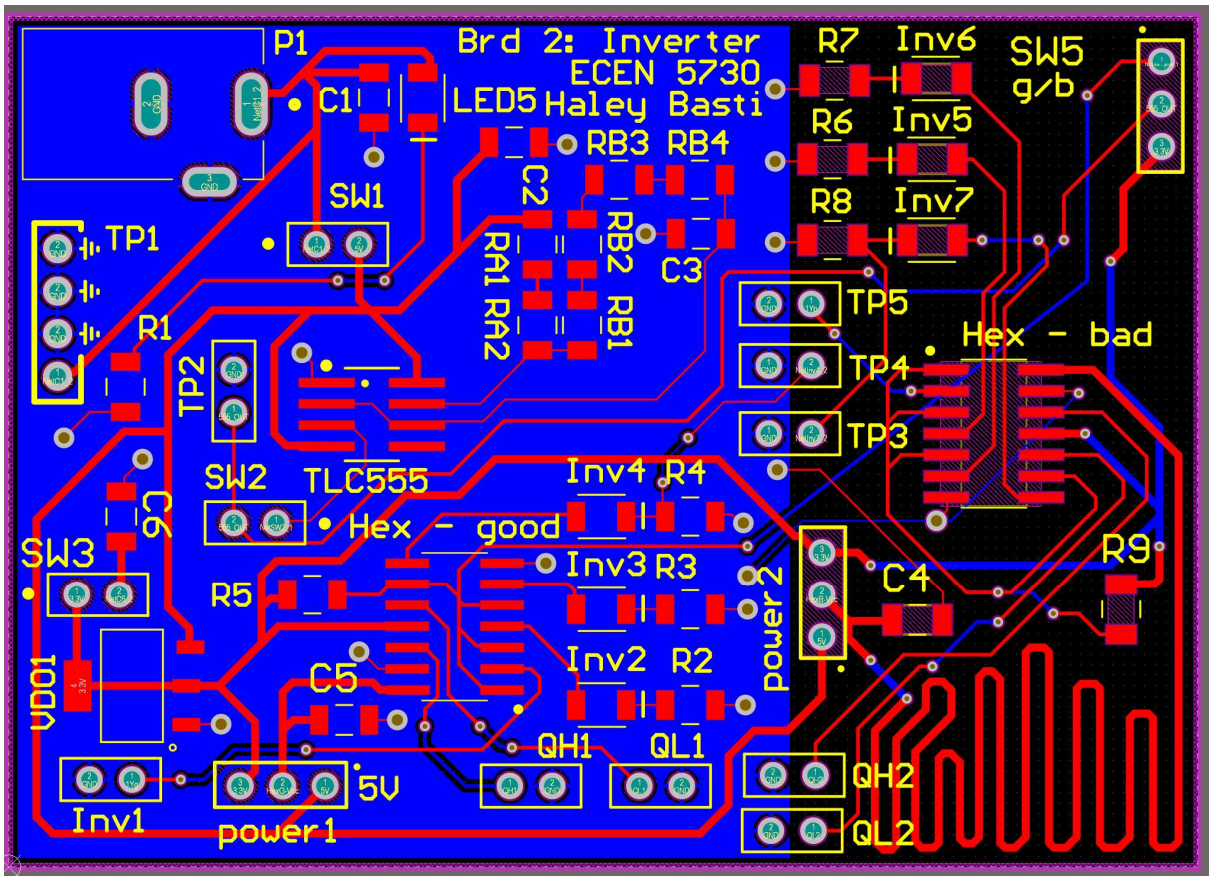


Old version

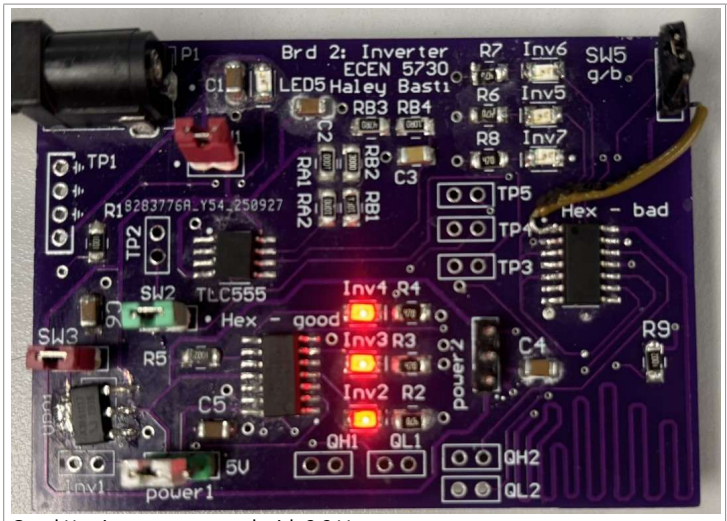


Cleaned up version

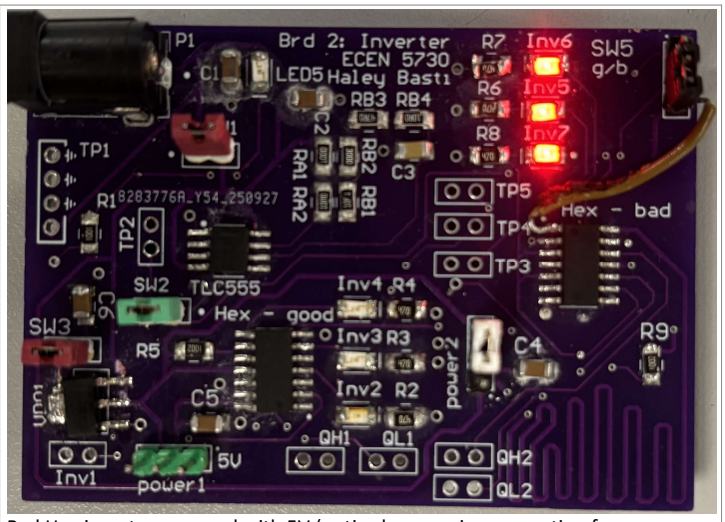
The board layout I ended up with is seen below. I should have noticed that pin 3 of switch 5 in the upper right corner was a 20 mil trace width, indicating that it was carrying power, and not a signal. The "bad" hex inverter input did have a long distance to travel, with no ground plane beneath it, setting me up for getting a good view of the consequences of bad power integrity practices.



The 555 output toggling problem was fixed by scratching out the connection from 3.3V to that pin, and soldering a wire to the input of the bad hex inverter:



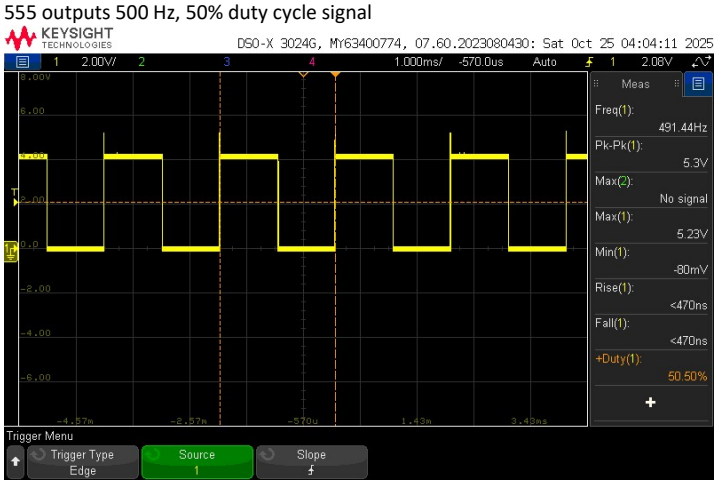
Good Hex inverter powered with 3.3 V



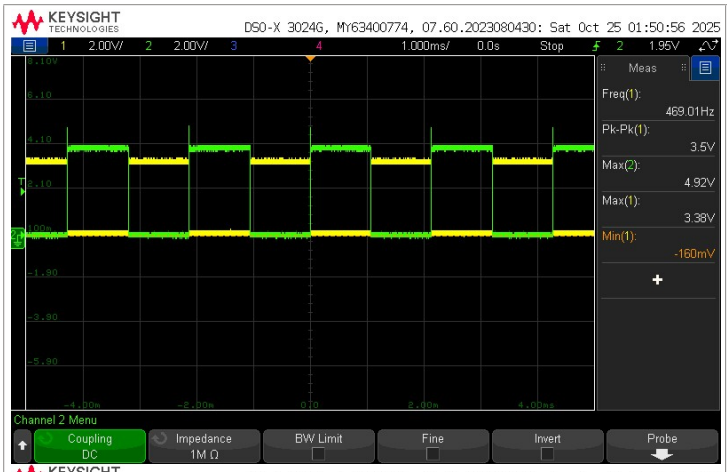
Bad Hex inverter powered with 5V (notice brown wire connection from header pin to inverter input)

What worked:

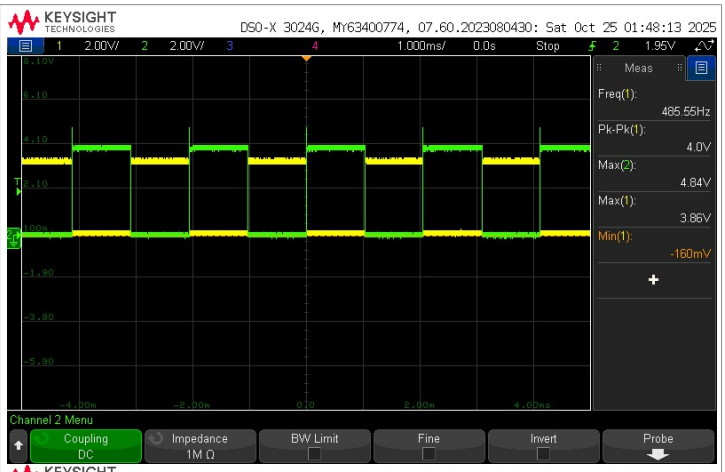
✓ 555 outputs 500 Hz, 50% duty cycle signal



✓ Inverters are shown to properly invert signal, with 3.3V and 5V on Vcc

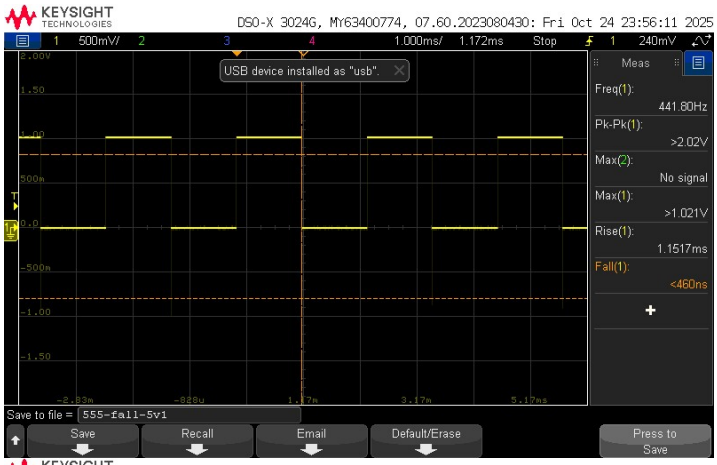


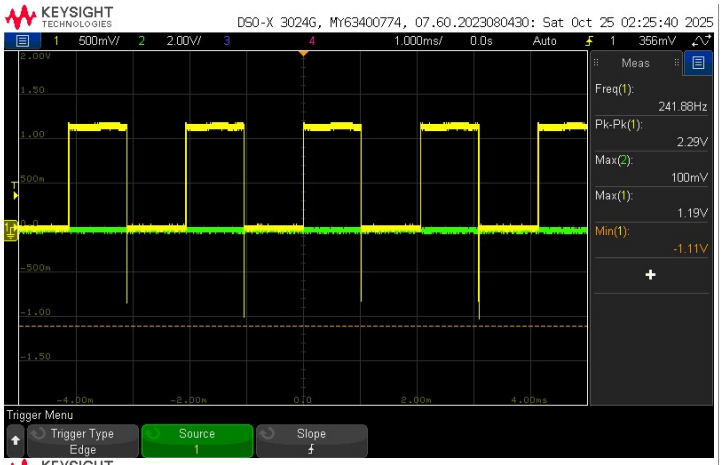
Inverter signal vs 555 timer on "Good" Hex for 3.3V and 5V Vcc inputs

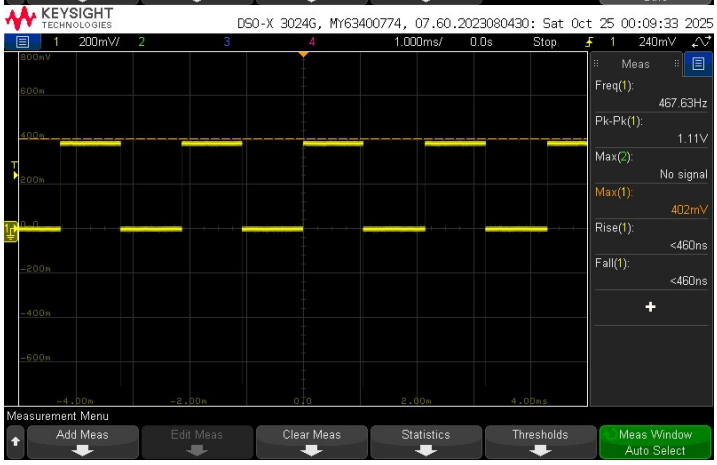


Inverter signal vs 555 timer on "Bad" Hex for 3.3V and 5V Vcc inputs

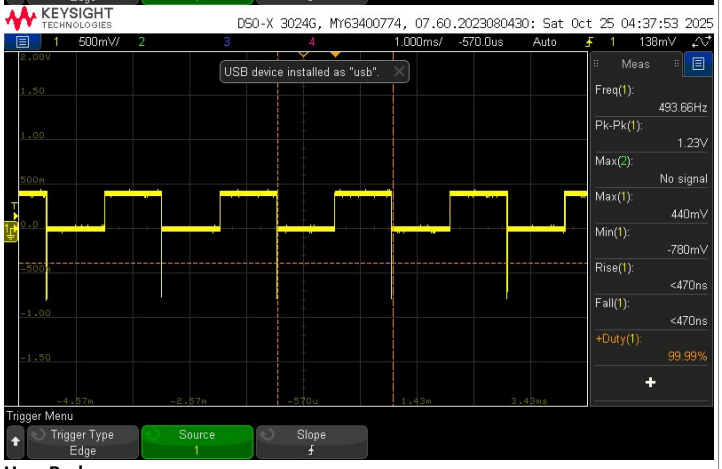
✓ LEDs turn on, measurement across resistors allows me to calculate current through the resistors







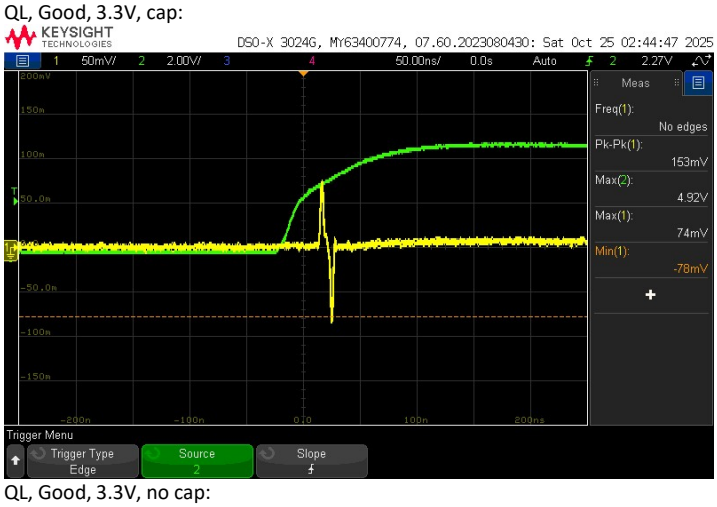
Hex, Good:
1V/47 Ohm = 21.3 mA
400mV/47 Ohm = 8.5 mA



Hex, Bad:
1V/47 Ohm = 25.3 mA
400mV/47 Ohm = 9.4 mA

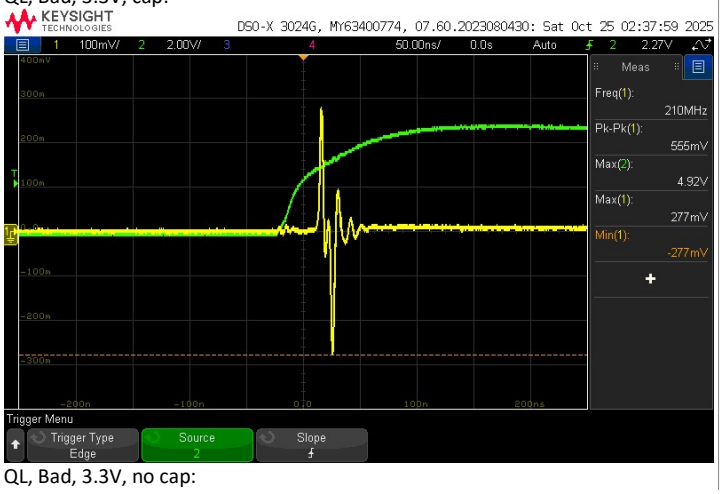
✓ Quiet High and Quiet Low measurements on "Good" inverter show less noise than the "Bad" inverter

QL, Good, 3.3V, cap:

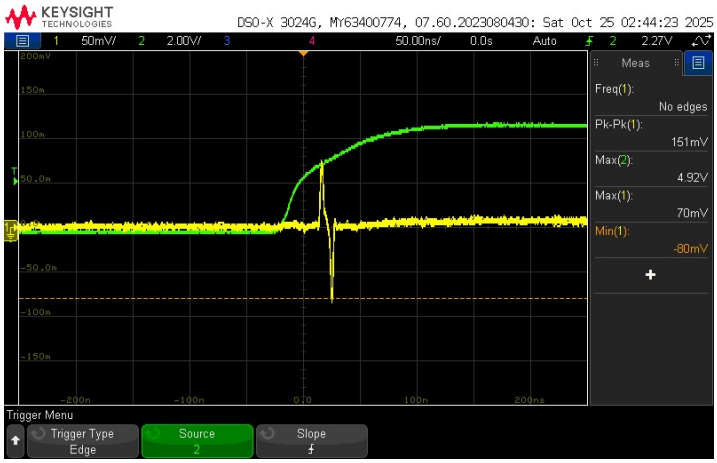


QL, Good, 3.3V, no cap:

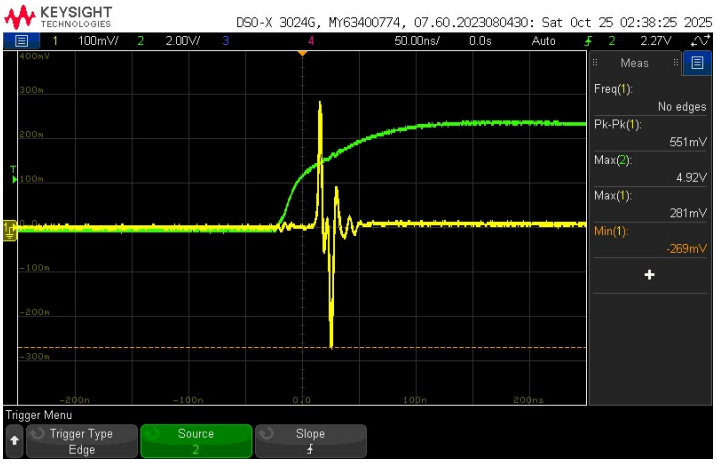
QL, Bad, 3.3V, cap:



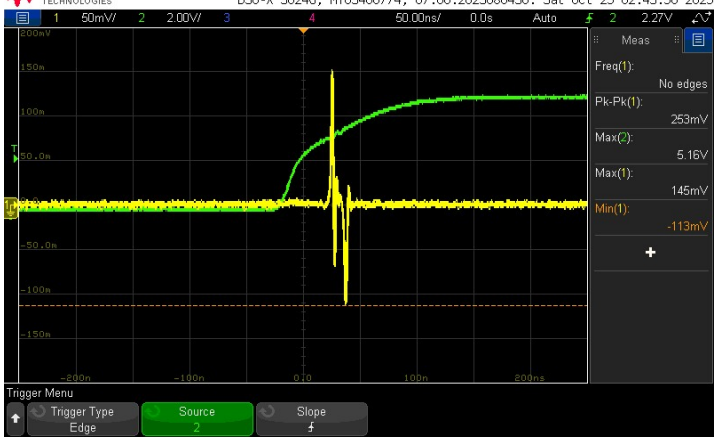
QL, Bad, 3.3V, no cap:



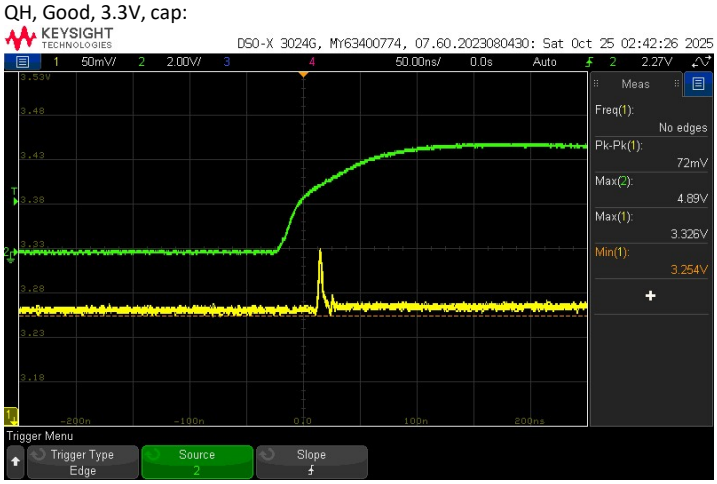
QL, Good, 5V:



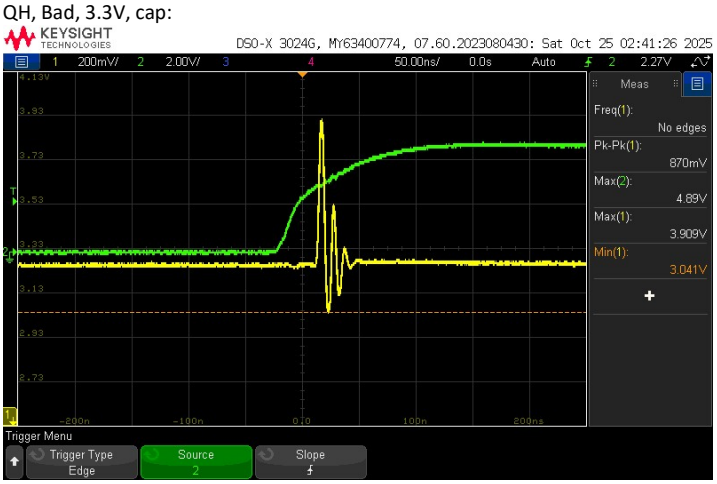
QL, Bad, 5V:



QH, Good, 3.3V, cap:

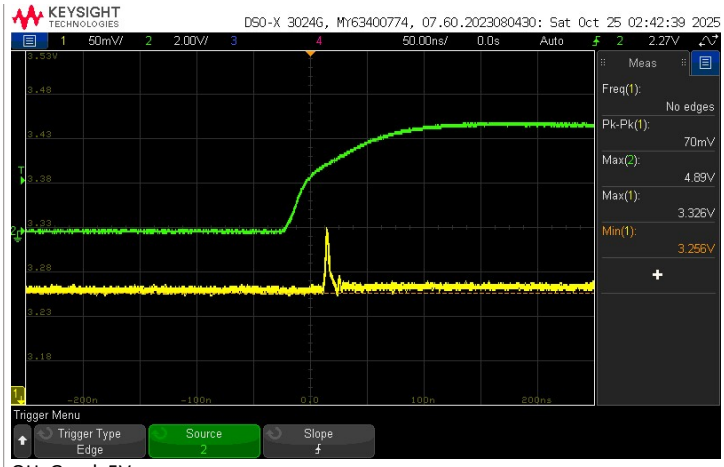


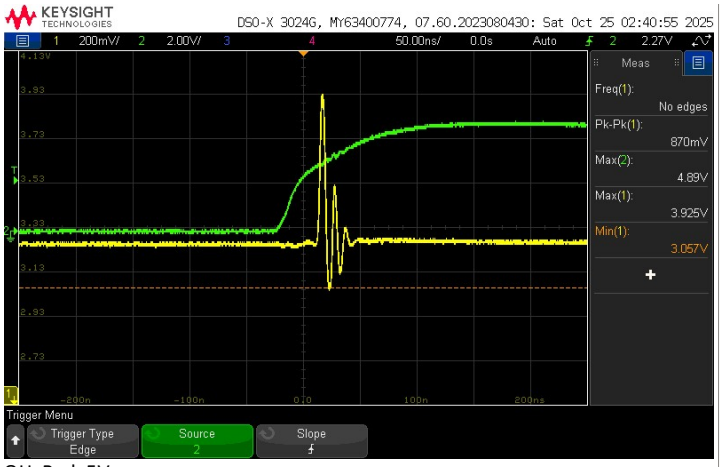
QH, Bad, 3.3V, cap:



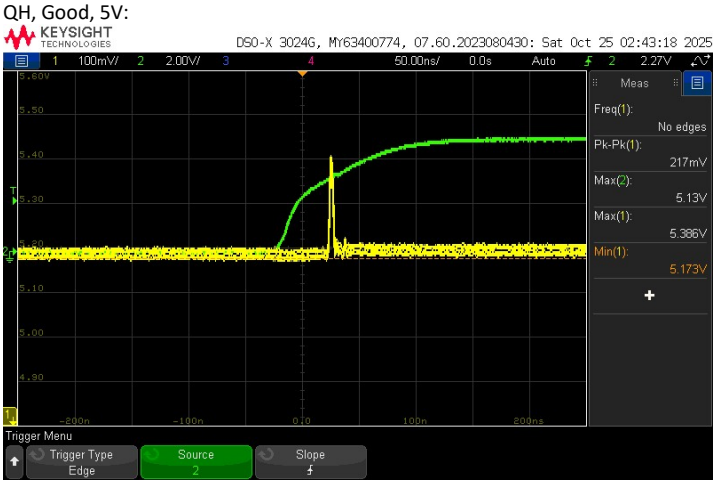
QH, Good, 3.3V, no cap:

QH, Bad, 3.3V, no cap:

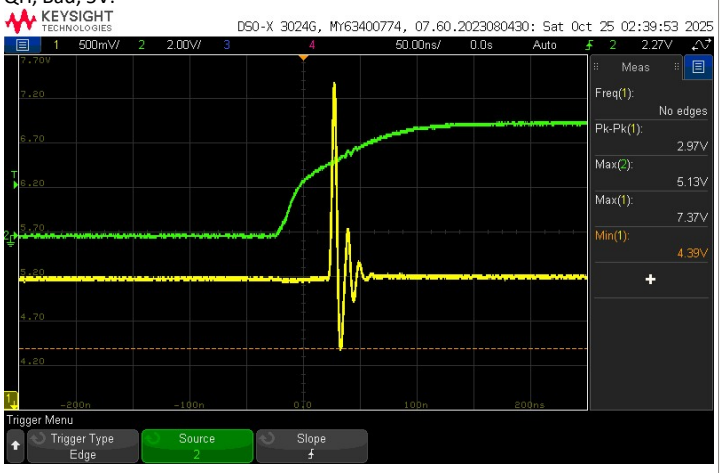




QH, Good, 5V:



QH, Bad, 5V:



What didn't work:

☹ Show effects of adding a decoupling capacitor to LDO:
I really didn't notice much of a change with adding the decoupling capacitor to the LDO, in spite of using a 22 uF capacitor

☹ I should have made the Quiet Low input the same as the Vcc input to the hex inverters,it sits at a constant 3.3V

- This also made it so when the switch to the Vcc input of the Hex inverters was open, a voltage of ~2.12V was visible on the Vcc input which caused the LEDs to light up

Analysis

	Good (mVpp)	Bad (mVpp)
Quiet low noise, 3.3V LDO cap -	153	555
Quiet low noise, 3.3V *no* cap -	151	551
Quiet low noise, 5V -	253	1010
Quiet high noise, 3.3V, LDO cap -	72	870
Quiet high noise, 3.3V, *no* LDO cap -	70	870
Quiet high noise, 5V -	217	2970

Hard errors:

- No way to toggle Quiet Low input voltage, Vcc pin of inverter input always carries some sort of voltage causing LEDs to light up
- Bad Hex inverter input carrying 3.3 V instead of signal - a soldered on wire would not be acceptable in real world applications

Soft errors:

- Perhaps too small of a decoupling capacitance on LDO? - no change in results
- The LED indicator on my power jack originally worked, but part of the way through testing it stopped working.
- Used the wrong footprint for test points (2 pin instead of 4), it made taking measurements with the scope probe very difficult.

Clearly, there is a reason we use best practices in designing our boards, as the results show a wide variation between the measurements of the two inverters. The zoomed out images in of the signal through the LEDs is very interesting, as it shows the massive fall time discrepancy between the two layouts.
In future designs, I will definitely be using Net labels in order to make my design clear and less confusing to avoid the two problems I encountered in this board layout. There is also an obvious benefit to using a continuous ground plane and shorter power traces.