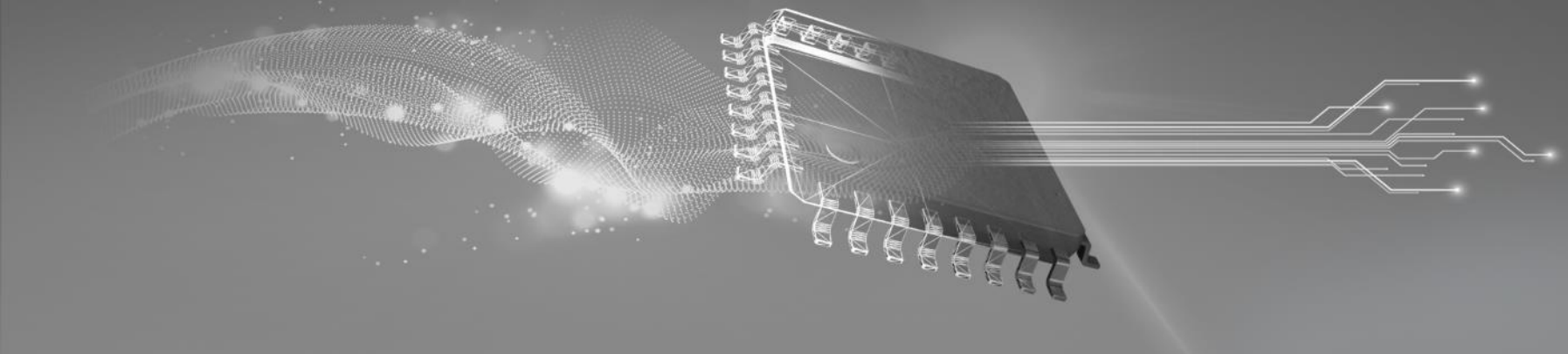
TI TECH DAYS



How to trouble shoot Op Amp PCB layout issues with real world examples

Tim Claycomb

General Purpose Amplifiers

Texas Instruments

Summary

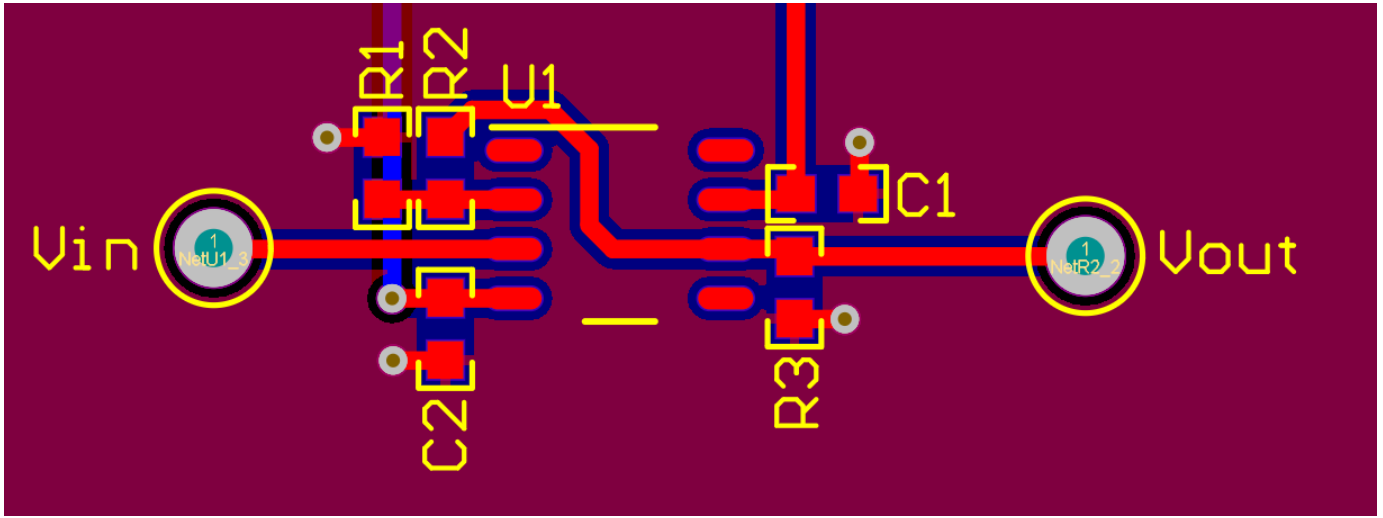
1) General op amp PCB layout recommendations

2) What to look for during PCB layout with examples

3) Conclusion

General PCB Layout Recommendations

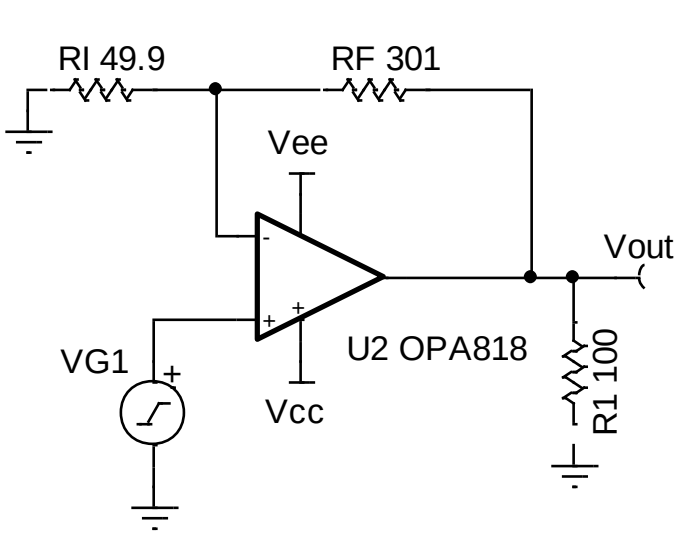
1) Minimize trace length on the inverting input pin
2) Place decoupling capacitors as close to the supply pin as possible
3) Do not place vias between decoupling capacitor and supply pin
4) Pour at least one solid ground plane
5) Make traces as wide as possible
6) Consider using a current limiting series resistor between inputs and low impedance connection (GND)
7) Place GND vias next to GND connections of components

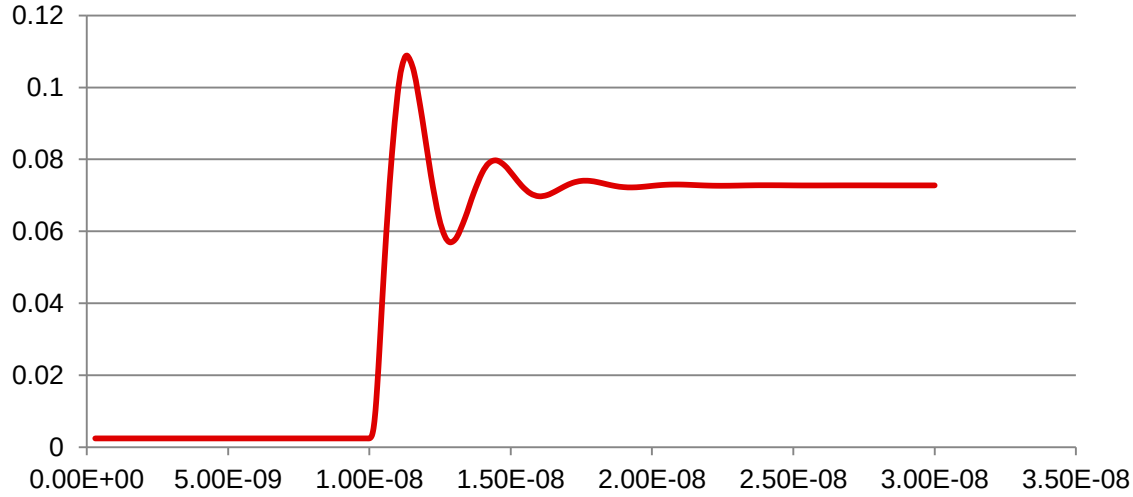


What to look for during PCB layout

Look for Long Traces on IN-

Description of Issue: Excessive overshoot and ringing on output of amplifier
Possible layout issue: Capacitance on inverting input pin of amplifier in high speed circuits and high value feedback resistors.

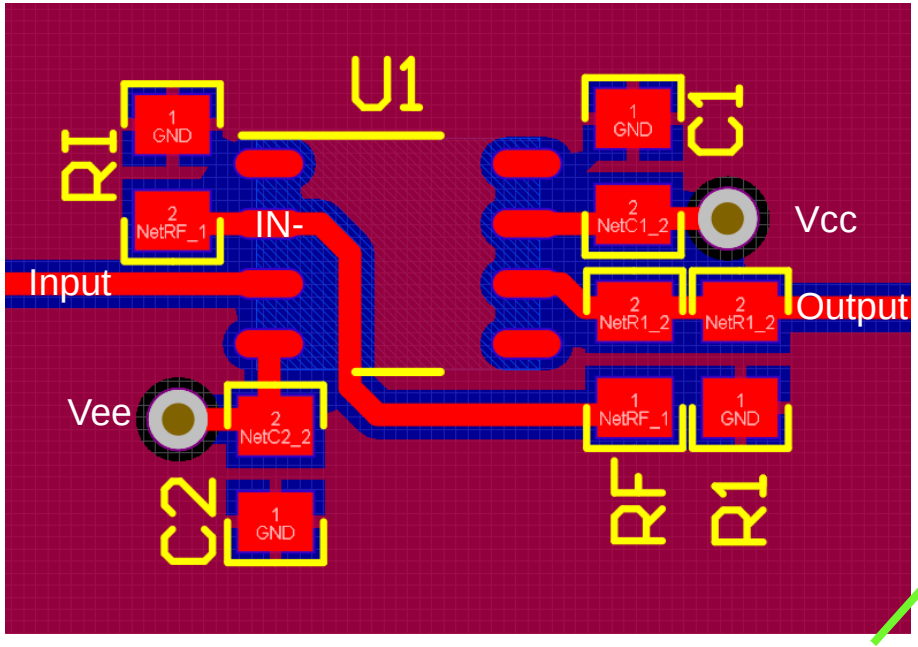




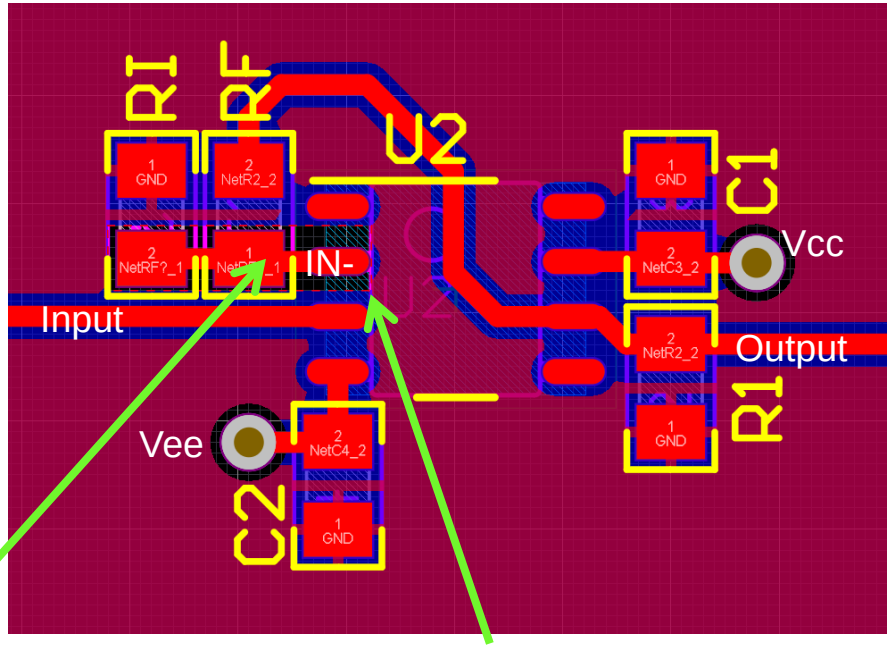
~50% Overshoot = 25 degrees of Phase Margin

Look for Long Traces on IN-

Current Layout



Improved Layout

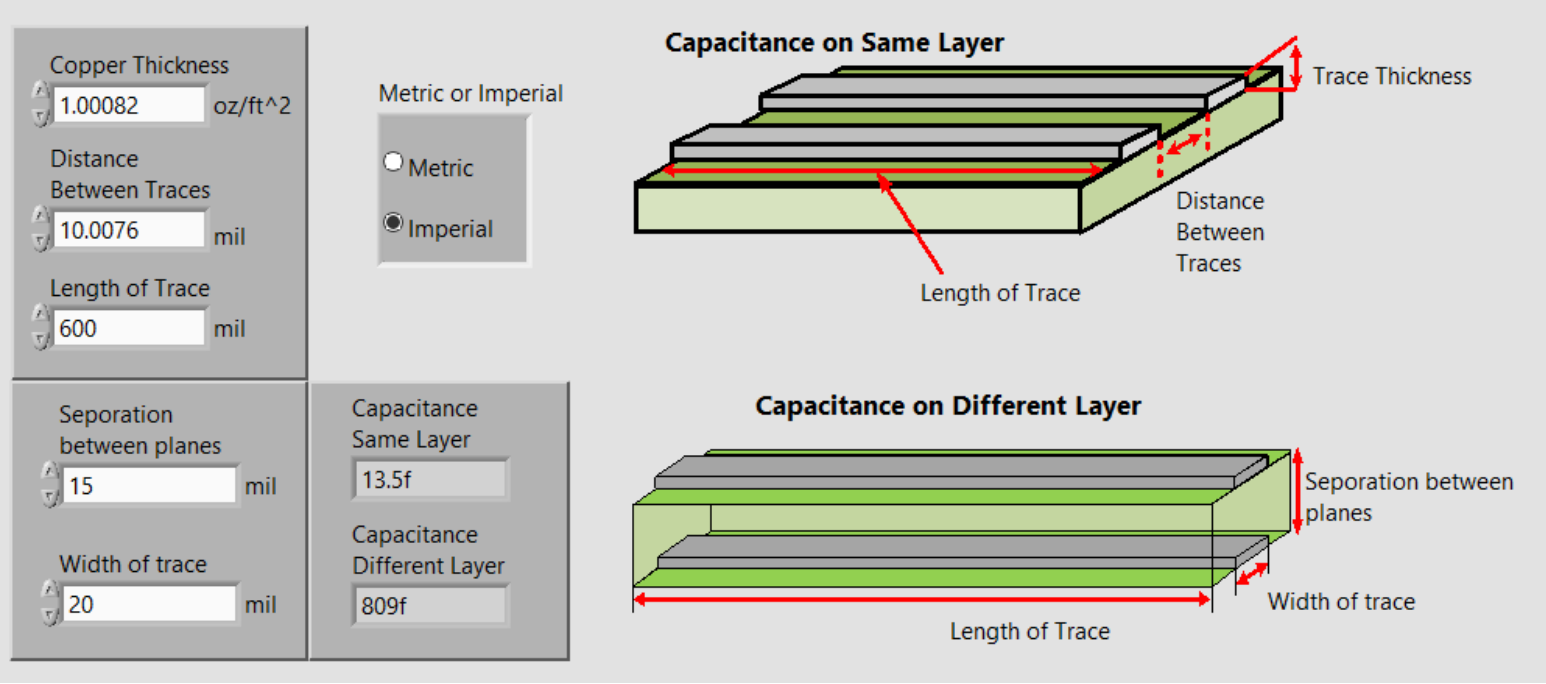


Inverting input traces kept as small as possible

Ground plane removed from inverting input node to reduce stray capacitance

Capacitor is two parallel plates

Look for Long Traces on IN-

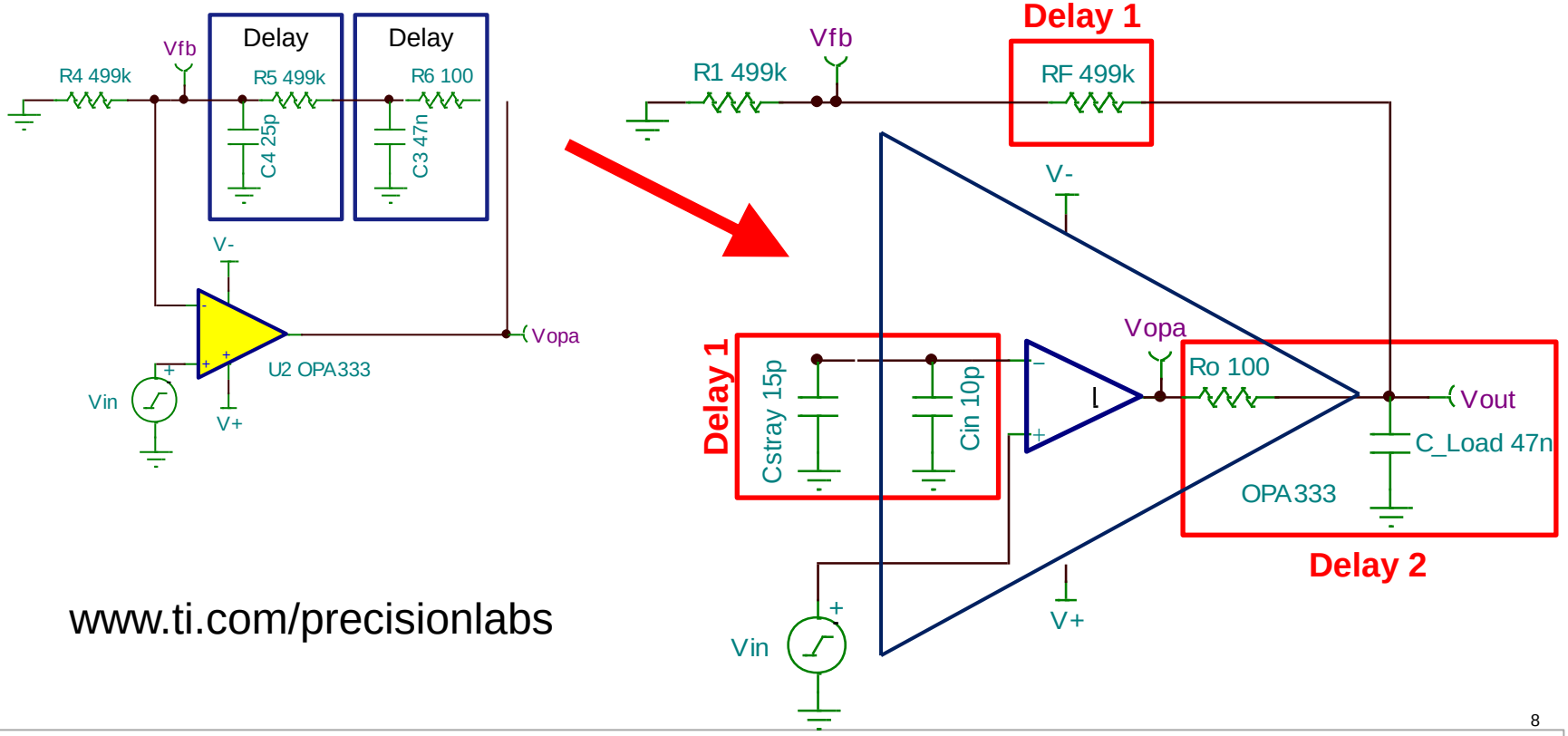


http://www.ti.com/tool/ANALOG-ENGINEER-CALC

~1pF from trace

Look for Long Traces on IN-

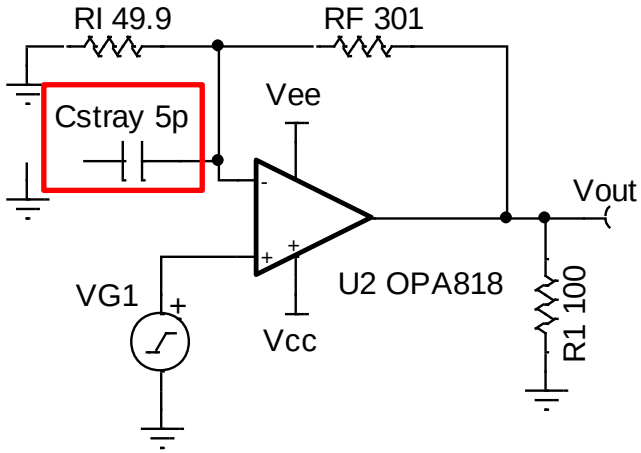
- Stability Issues occur because of too much delay in the feedback

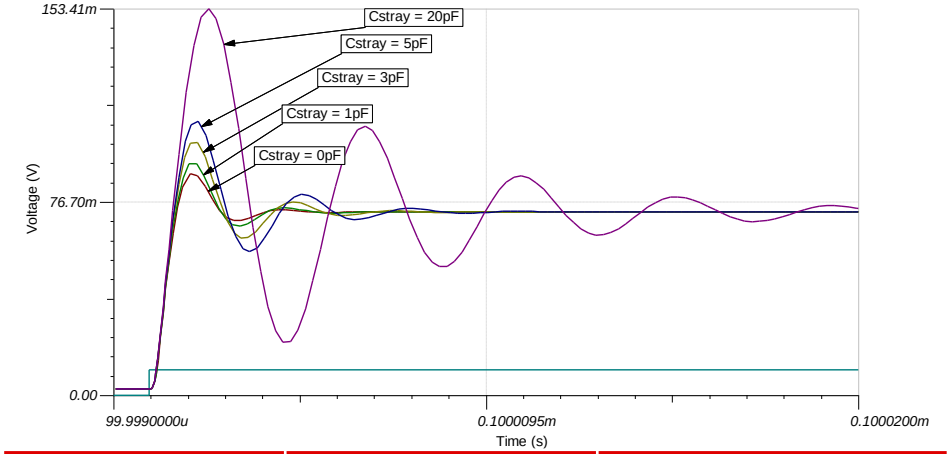


www.ti.com/precisionlabs

Large overshoot? Think Stability

Look for Long Traces on IN-



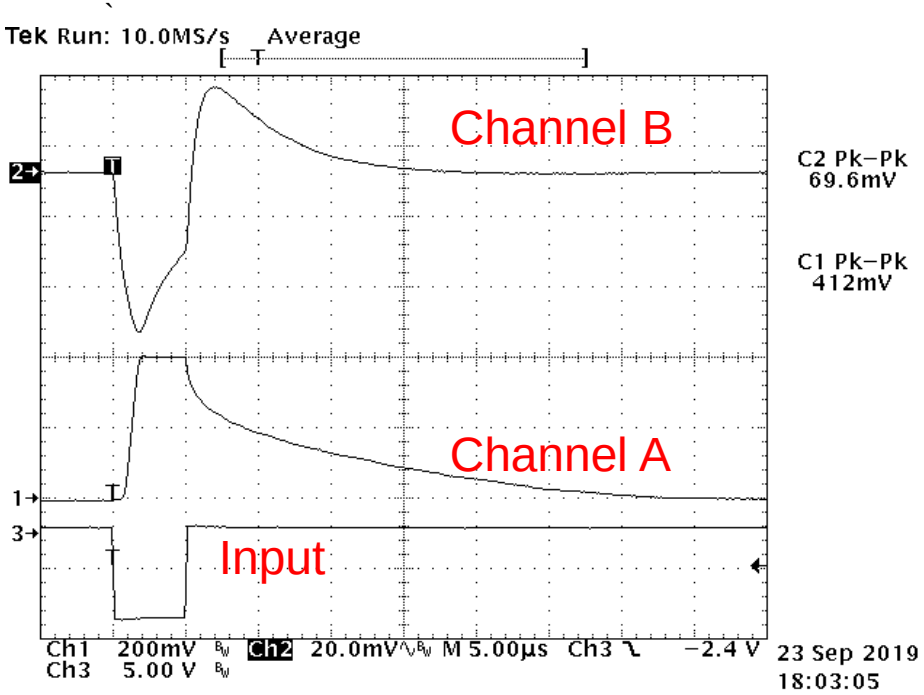


Cstray	Overshoot	Phase Margin
0pF	17mV / 24%	44 °
1pF	21mV / 30%	39 °
3pF	30mV / 42%	29 °
5pF	38mV / 54%	21°
20pF	83mV / 118%	6°

Increase Cstray, increase %OS

Look for Parallel Traces

Description of Issue: Channel A (high output current) output is influencing CH B (TIA) – crosstalk?
Possible layout issue: Coupling due to PCB traces routed parallel and close together

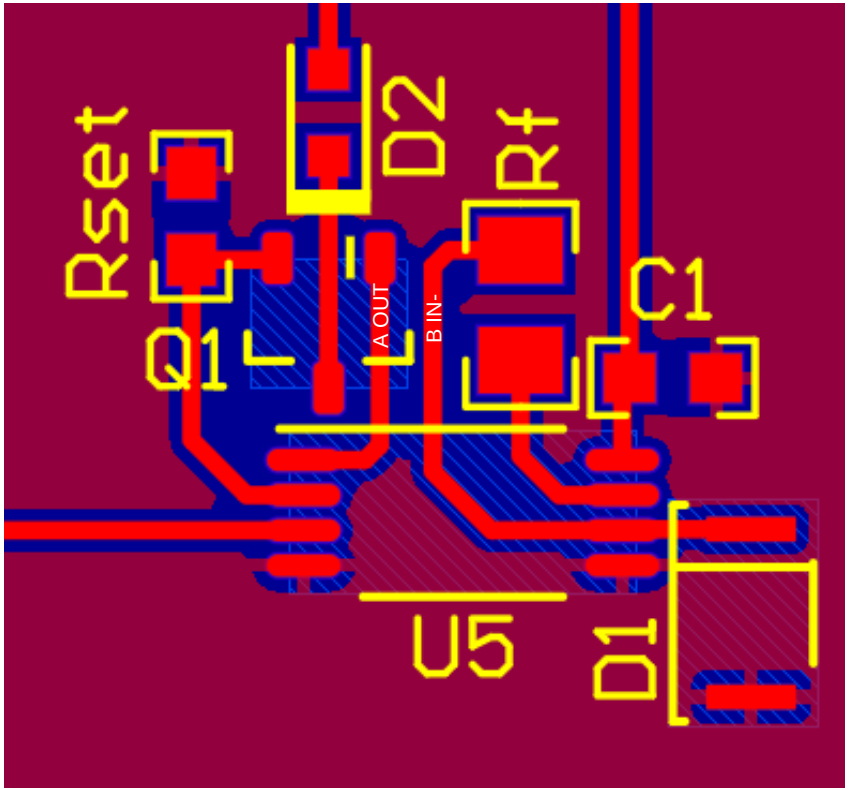


Crosstalk of TLV9062 = 100dB

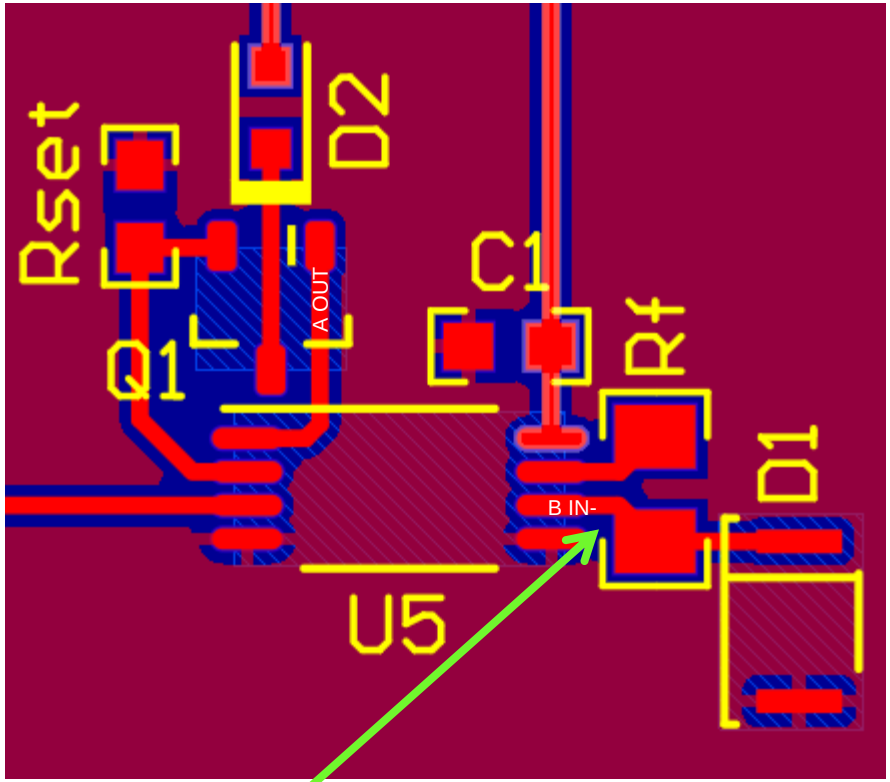
Crosstalk of PCB = ~15dB

Look for Parallel Traces

Current Layout



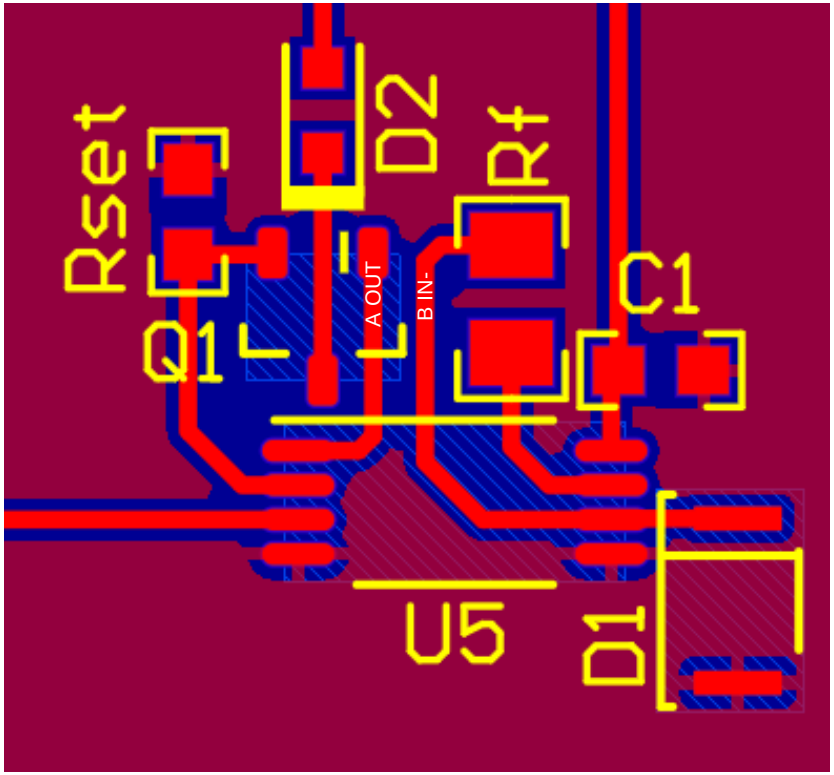
Improved Layout



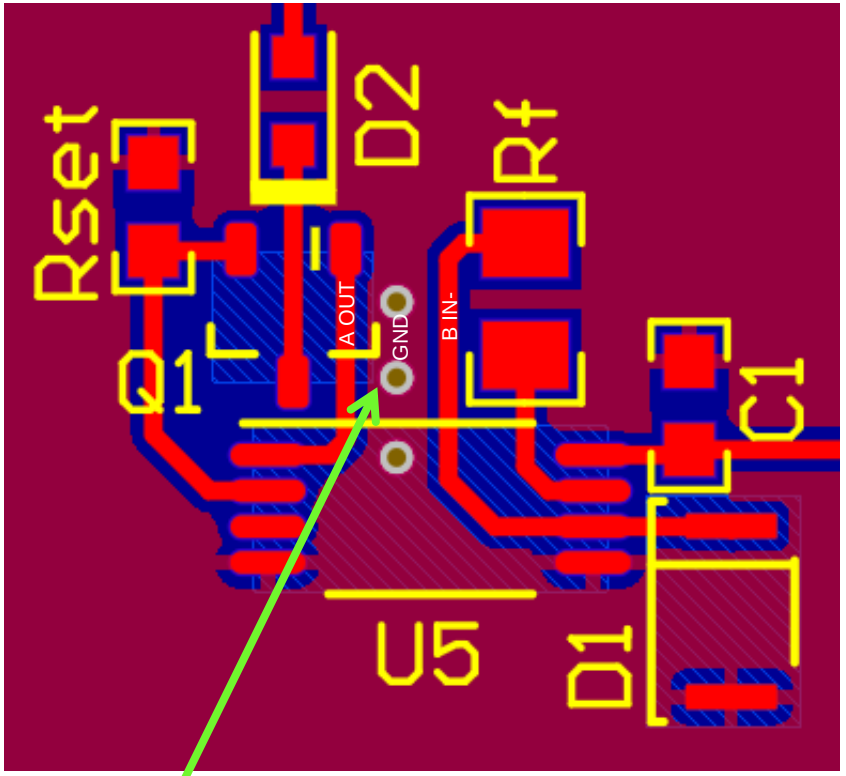
Move Rf away from CH A Output

Look for Parallel Traces

Current Layout



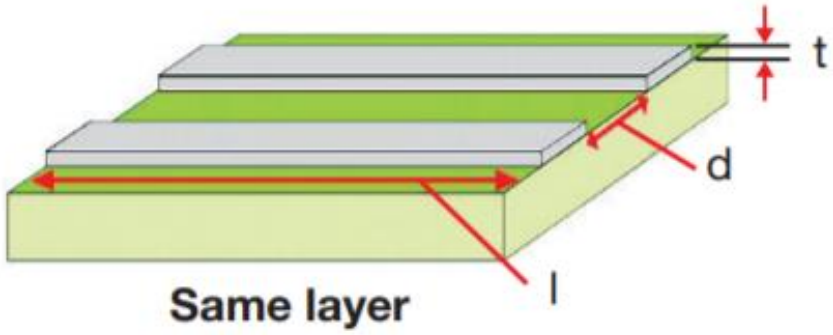
Improved Layout



Add GND pour with vias between CH A Output and CH B IN-

Look for Parallel Traces

- The closer two traces are to each other the more capacitance there is between them.



$$C = \frac{k \times t \times l}{d}$$

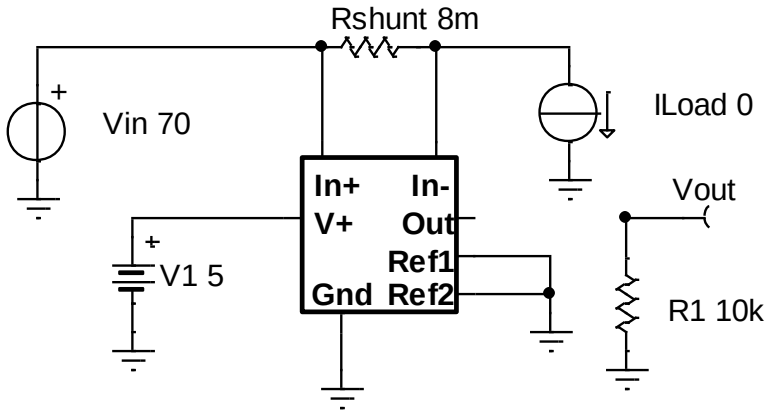
Analog Engineer's Pocket Reference
http://www.ti.com/lit/slyw038

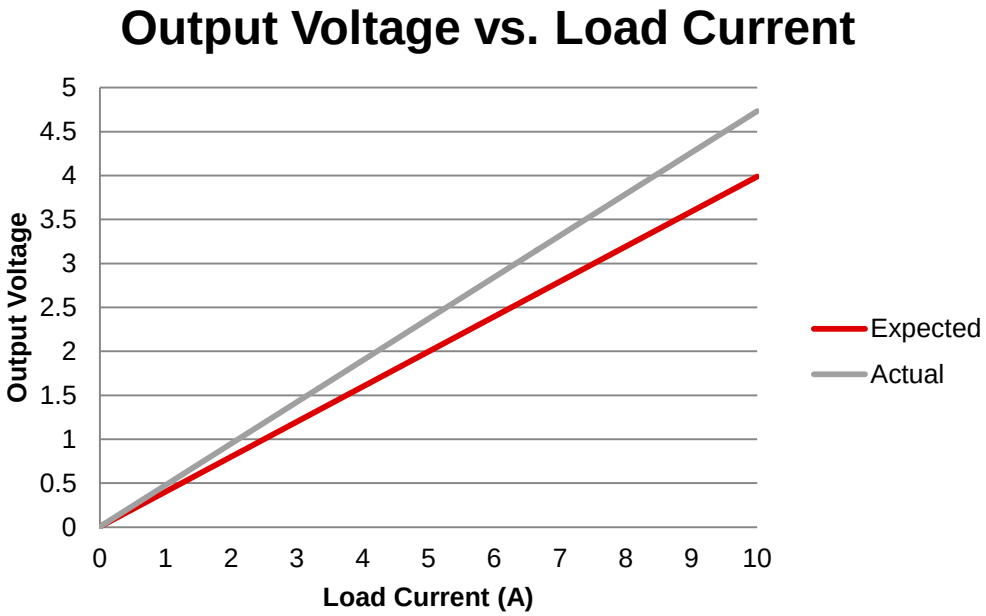
C decreases as distance increases

Look for Kelvin Connection on Rshunt

Description of Issue: Seeing high gain error in current sensing application
Possible layout issue: Not using a Kelvin connection

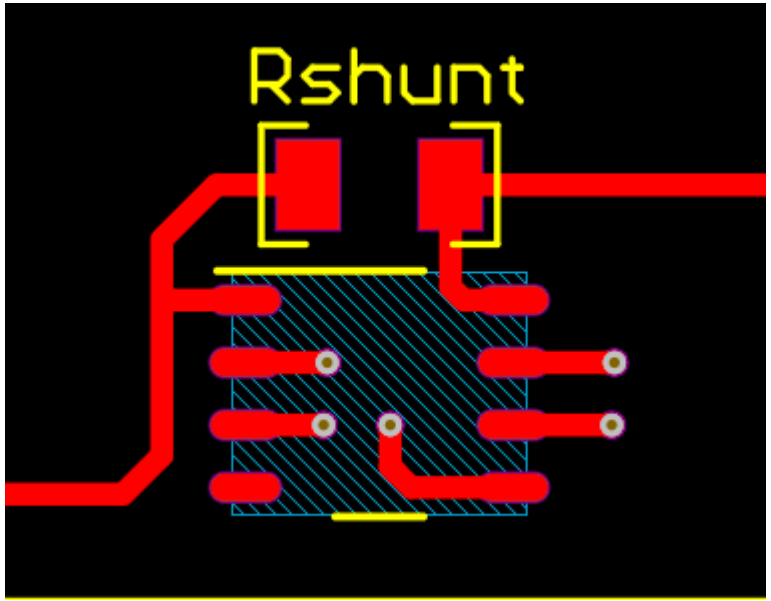
-



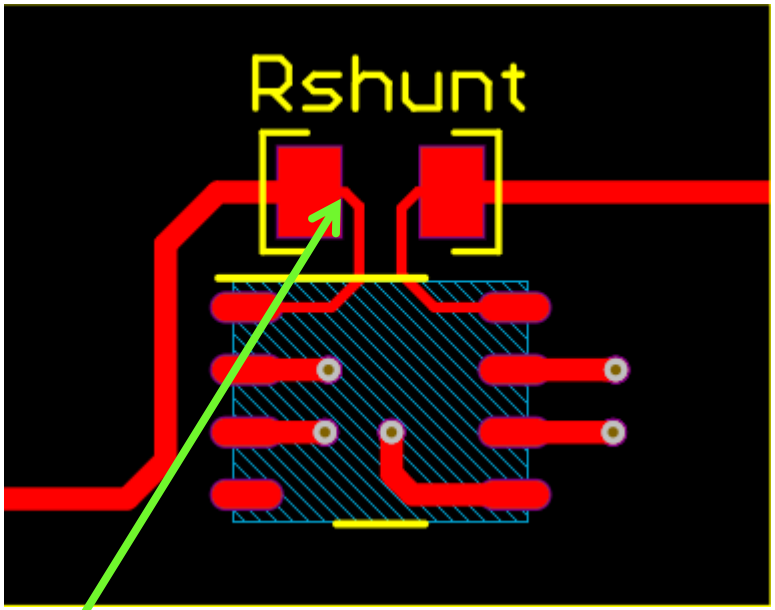


Look for Kelvin Connection on Rshunt

Current Layout



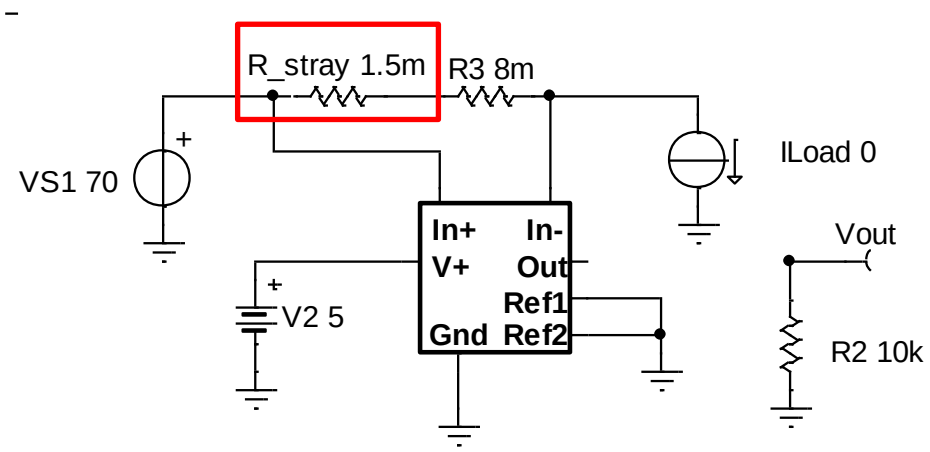
Improved Layout



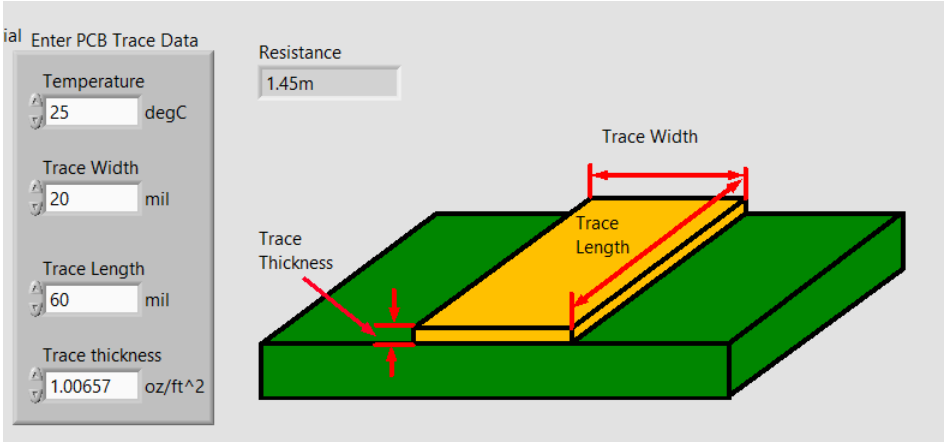
Kelvin connection to Rshunt

8mΩ shunt

Look for Kelvin Connection on Rshunt

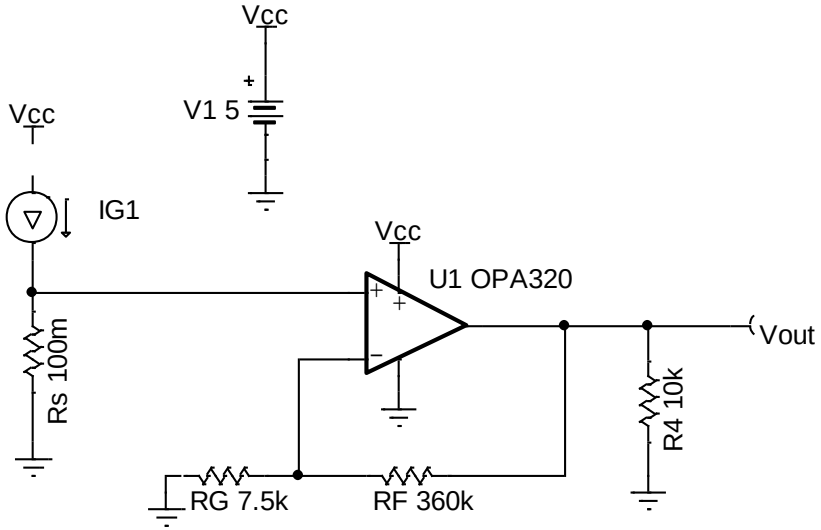


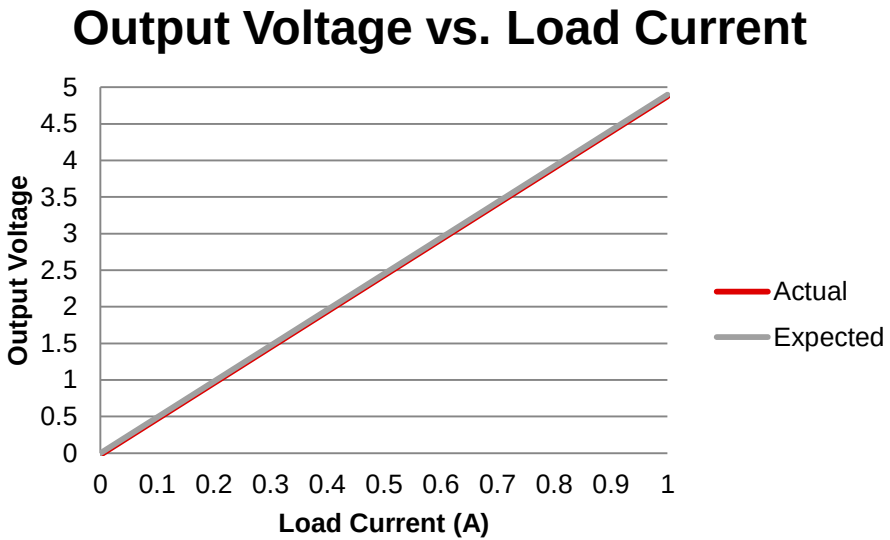
A 20mil wide 60mil long trace is approximately the size of an SOIC footprint pad.



Look for RG Placement

Description of Issue: Seeing high offset error in low-side current sensing application
Possible layout issue: Gain setting resistor not placed close to shunt



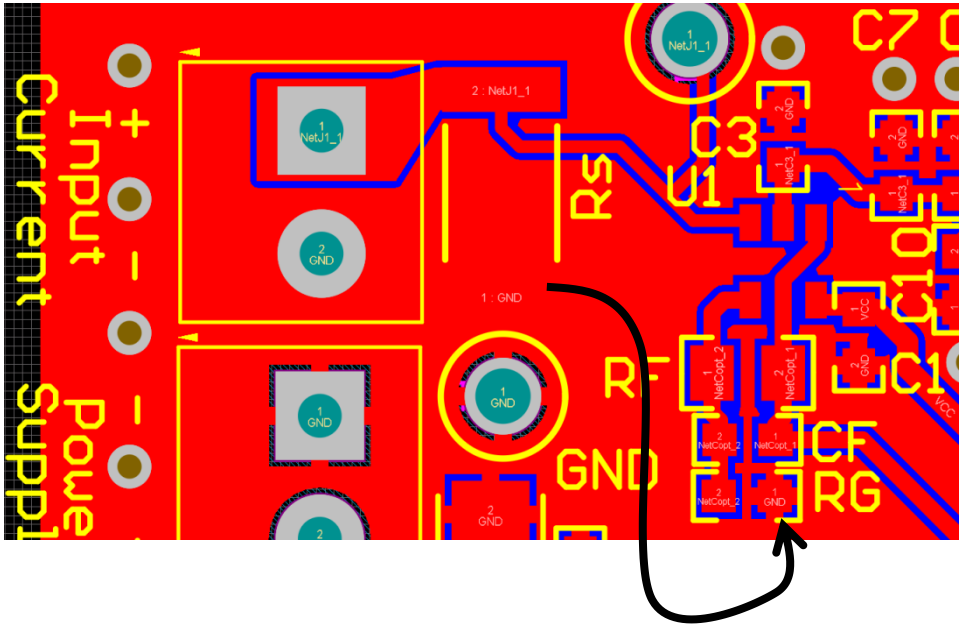


~25mV of offset on output

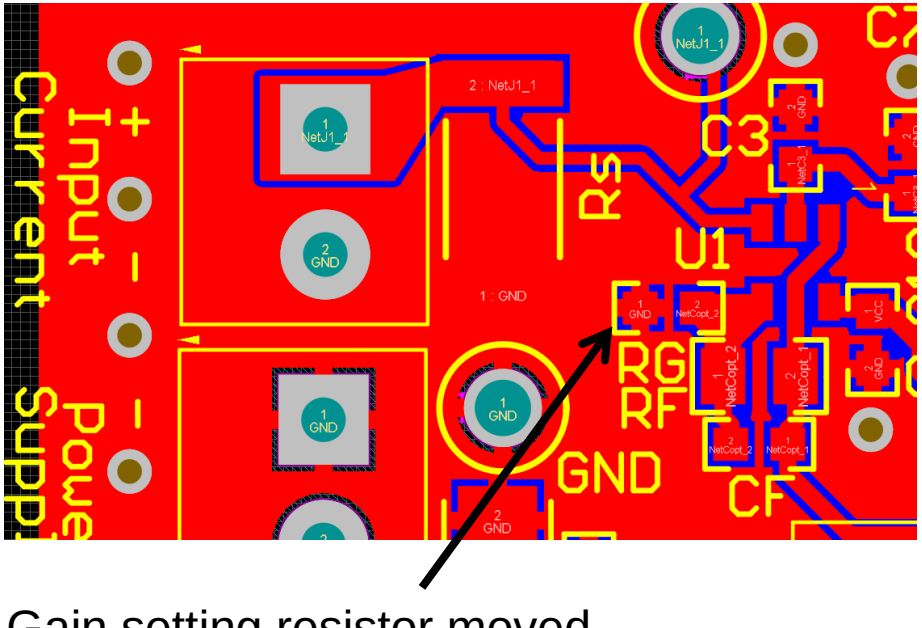
Vos Max = 150µV

Look for RG Placement

Current Layout

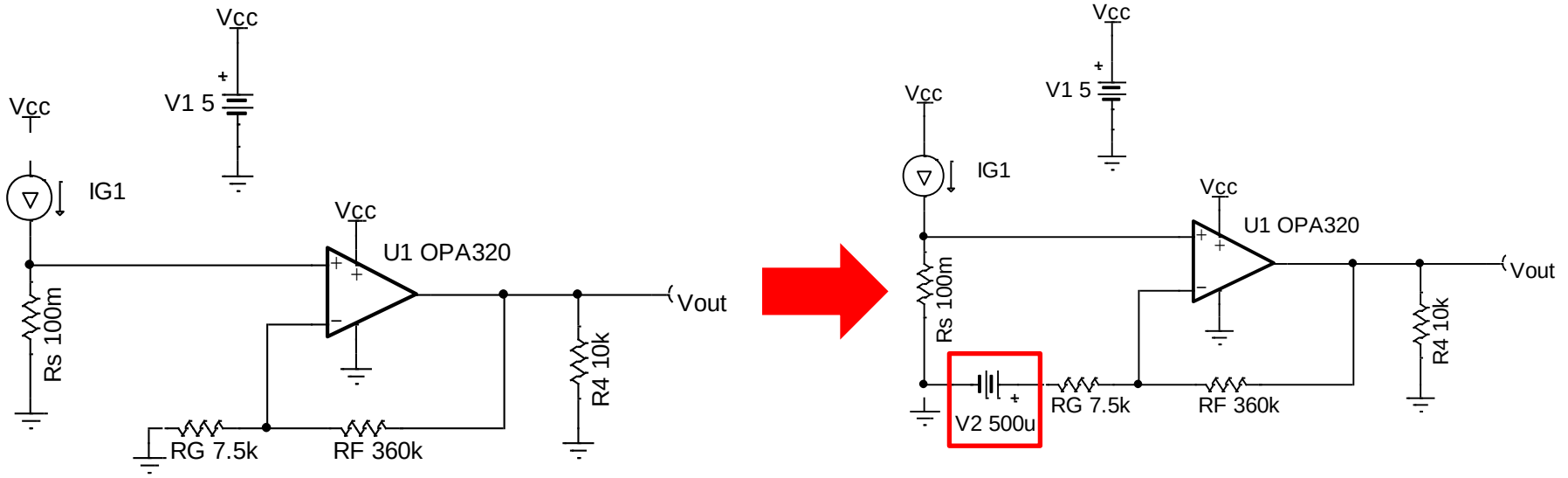


Improved Layout



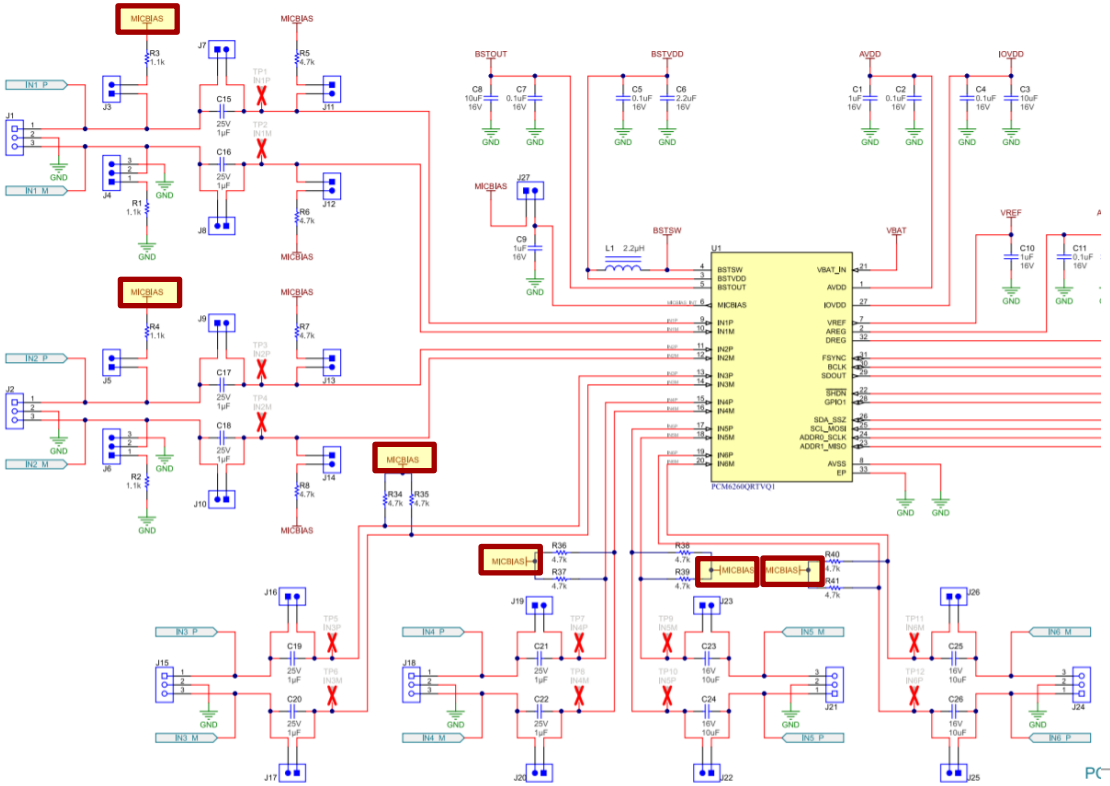
Gain setting resistor moved close to GND of shunt resistor

Look for RG Placement



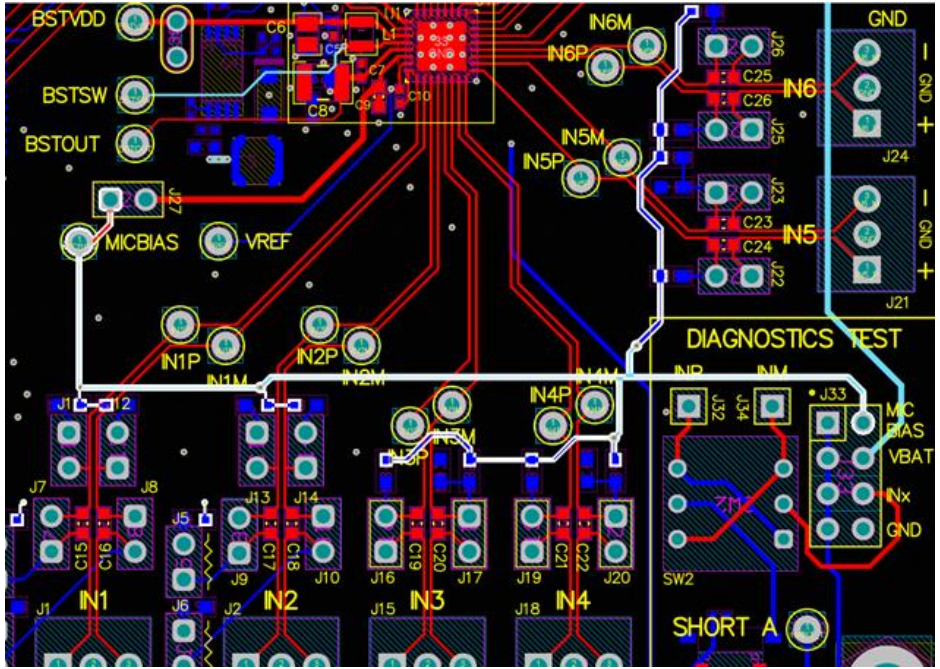
Look for Star Connection

Description of Issue: Crosstalk in multi-channel microphone circuit
Possible layout issue: Microphone bias voltage is not star connected



Look for Star Connection

Current Layout



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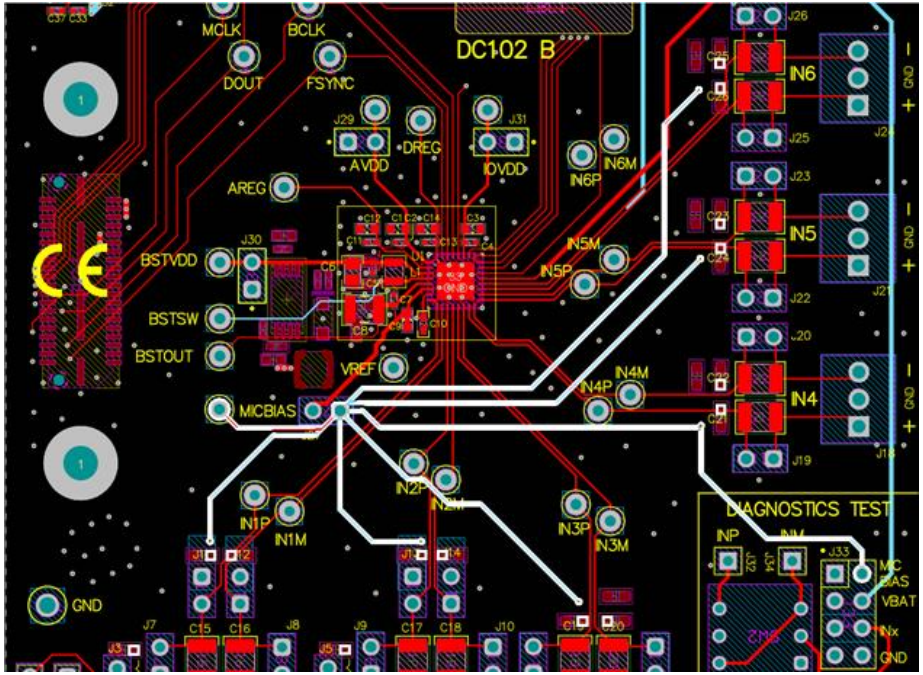
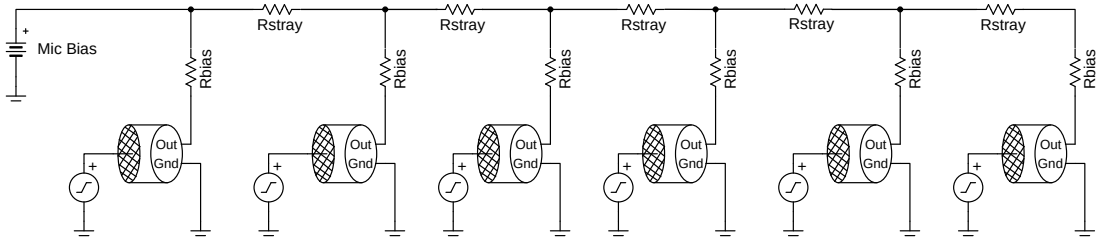
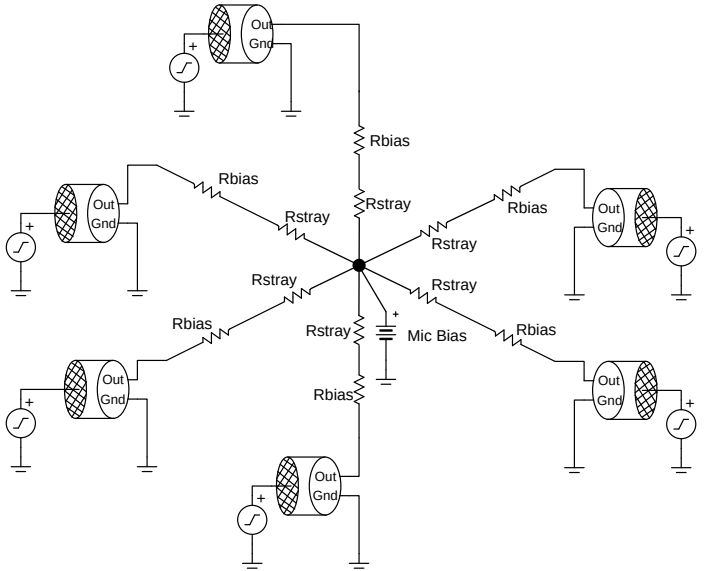


Look for Star Connection



Current Layout

Improved Layout



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