# Shunt Resistor Layout Considerations

## TI Precision Labs – Current Sense Amplifiers


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Hello and welcome to the TI precision labs series on current sense amplifiers. My name is Rajani Manchukonda, and I’m a product marketing engineer for current sensing products. In this video, we will discuss the guidelines for printed circuit board, or PCB, layout of the shunt resistor, or Rshunt, in current sense amplifier circuits.

# $R_{shunt}$ layout rules of thumb

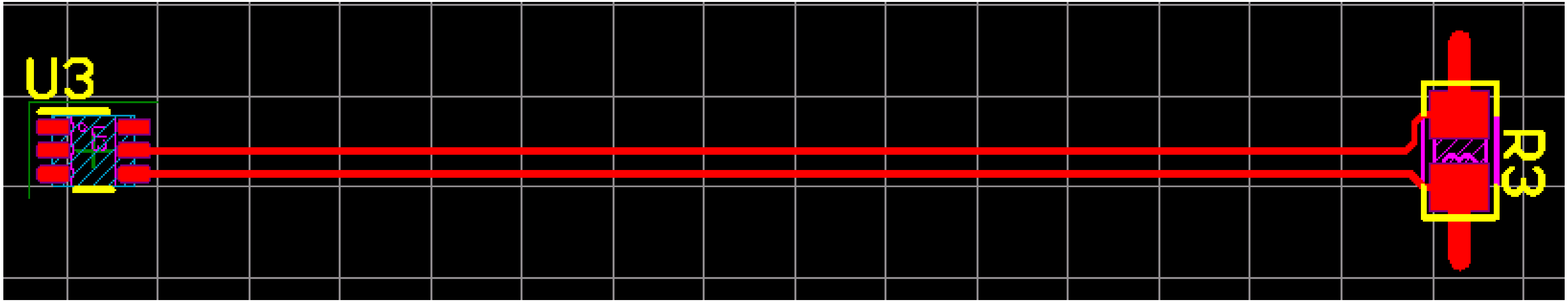
1. Be **close** to the current sense amplifier
2. Use **Kelvin** connections
3. Follow the resistor maker's **guidelines**
   a) Footprint
   b) Placement
   c) Landing pad design

The layout of a shunt resistor with respect to a current sense amplifier should follow these three rules of thumb:

1. Be close to the current shunt monitor
2. Use Kelvin connections
3. Follow the resistor maker's recommendations as applicable with regards to footprints, placement, and landing pad design.

Let's get into some details on each rule.

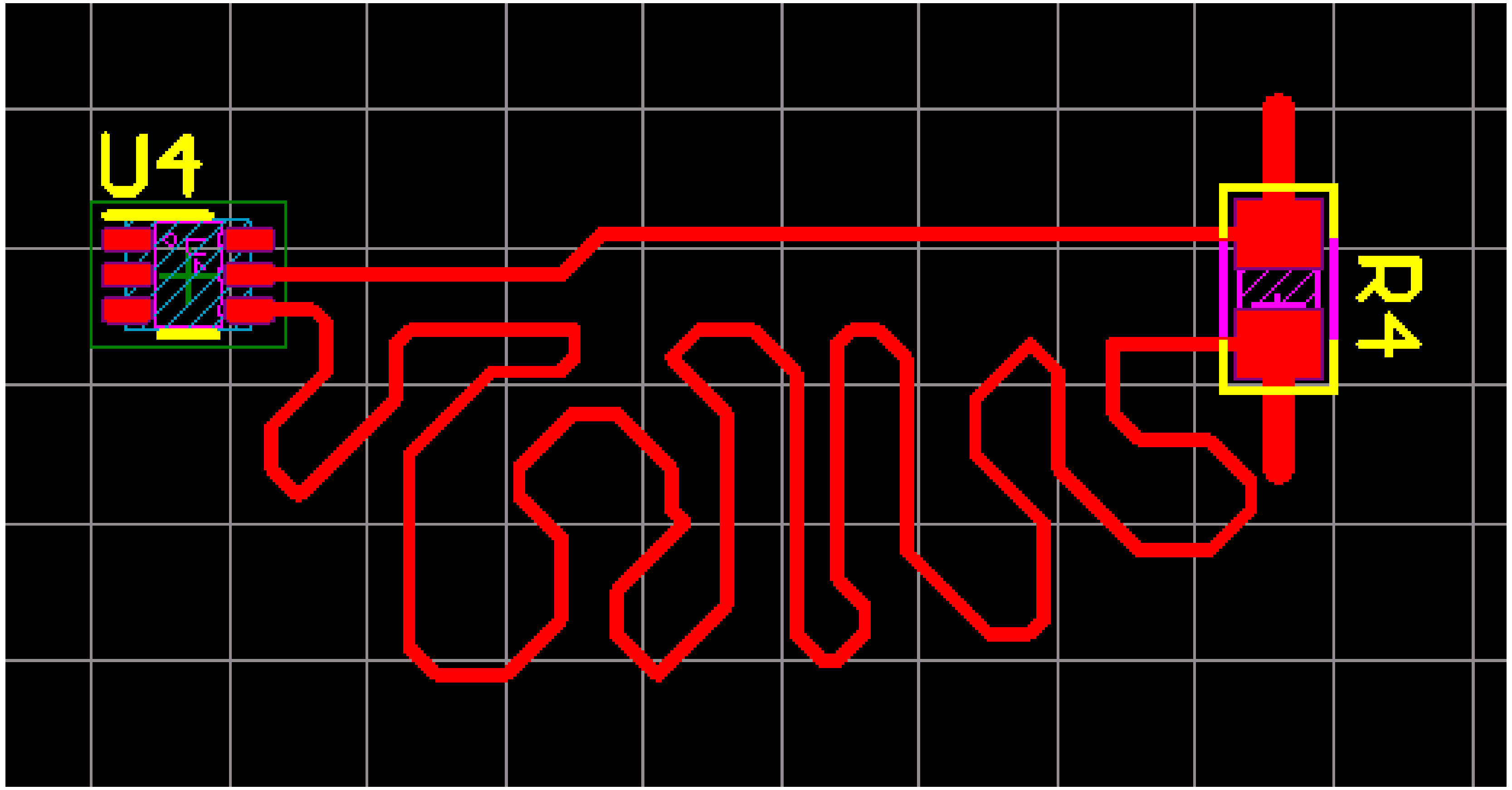
# Rule 1 – Be close to the current sense amplifier




Avoid **long** traces!

Placing the shunt resistor close to the amplifier is important as it avoids complications resulting from long traces. The voltage on these traces is small and the current is low, so electromagnetic interference and noise is a concern.  Also, the parasitic trace capacitance and resistance, while small, can add to the error of the system, especially is very low shunt resistances are used.

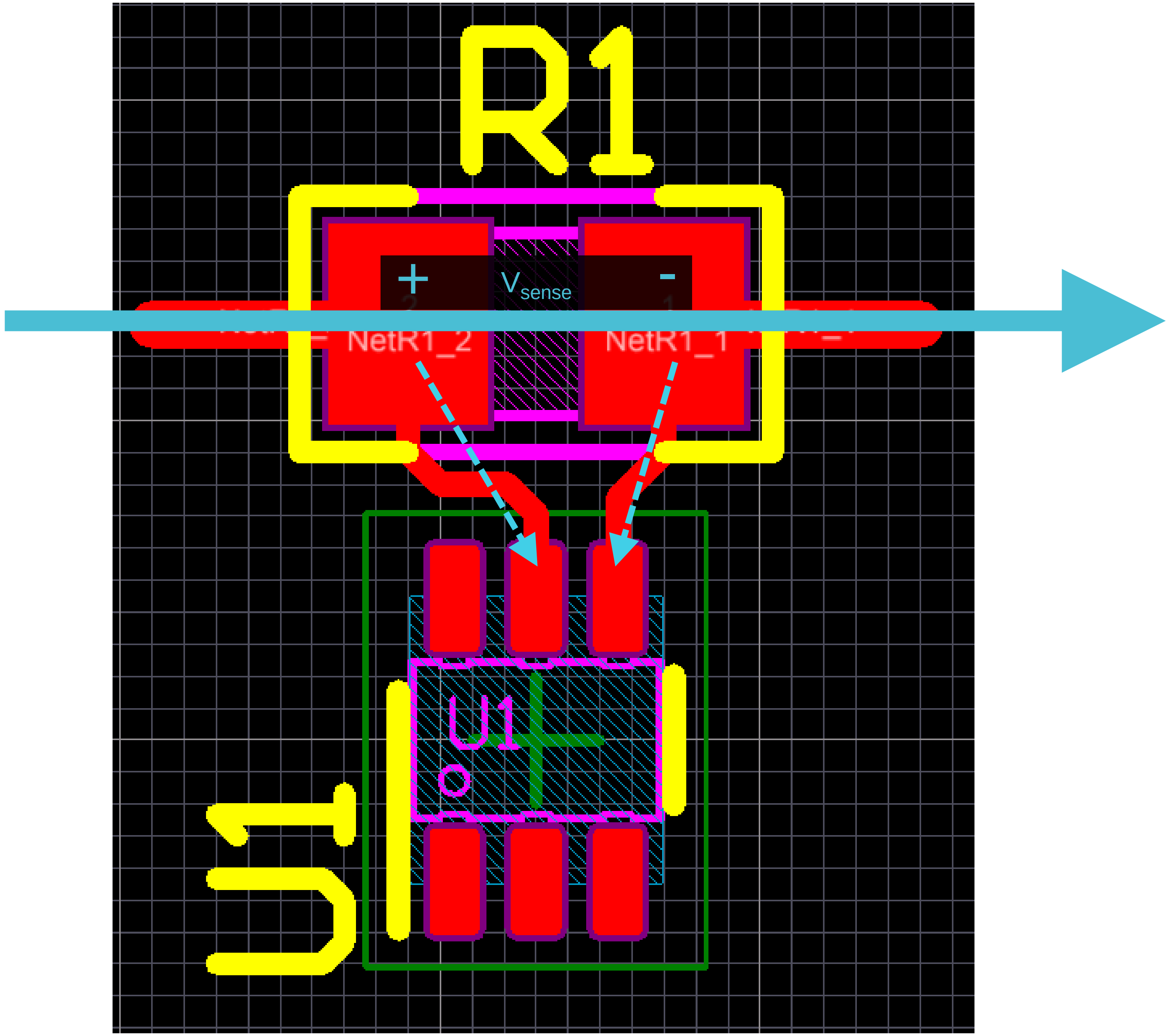
# Rule 1 – Be close to the current sense amplifier




Avoid **unbalanced** traces!

Using traces of mismatched lengths is also not recommended, for the same reasons as not using long traces.  While the case shown here is extreme, it is important to note that mismatches in the trace resistance from the shunt resistor to the amplifier can create offsets due to the input bias currents present on the lines.  These errors may be small, but it’s best to avoid the issue altogether.

# Rule 2 – Use Kelvin connections (good layout)

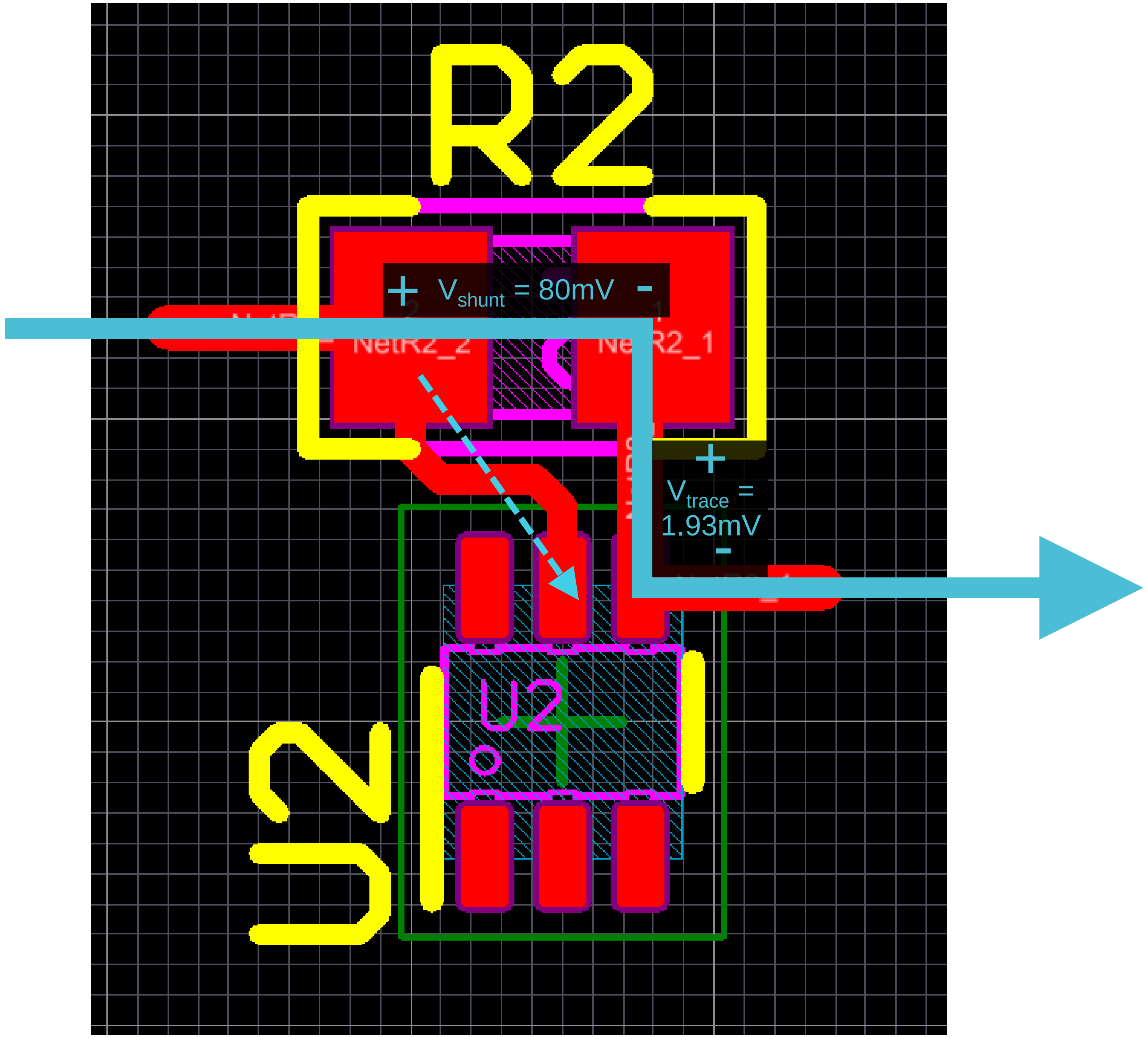


Here is an example of a good layout. Note that the shunt resistor is close to the amplifier.

1. The high current path goes from left to right, through the resistor and large load-carrying traces.
2. There are Kelvin connections from the resistor pads to the amplifier which provide the differential voltage to be measured. Trace lengths are very short.
The current flowing through these traces is minimal, usually around tens of microamps, so the voltage loss on the path from the resistor to the monitor is very low.

In summary, these techniques force the bulk of the current through the shunt resistor, and the value of the resistance seen by the current path will be close to the absolute value of the resistor. This enables the sense voltage Vsense to be accurately developed across Rshunt and passed to the current sense amplifier.

# Rule 2 – Use Kelvin connections (bad layout)



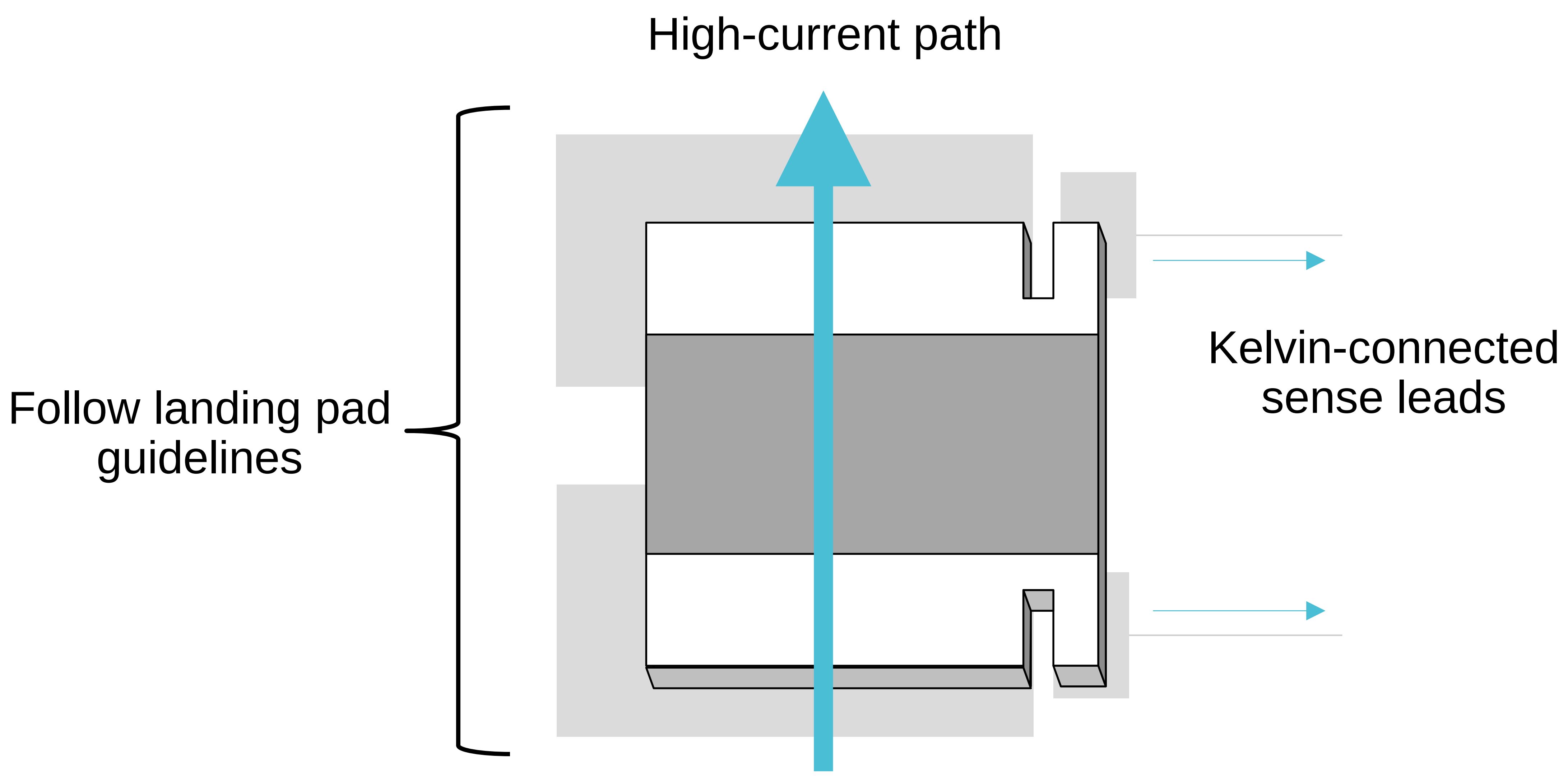
Here is an example of a bad layout. Note that the shunt resistor is still close to the amplifier.

1. Again, the high current path goes from left to right, through the resistor.
2. There is a Kelvin connection from the left side of the resistor to the amplifier, but the other pad is simply tied into the high current path.

The current flowing through the left trace is minimal, usually around tens of microamps, but the high-current path through the right trace can carry tens of amps! This means that the trace resistance will create a much larger error voltage than in the previous case, when Kelvin connections were used on both inputs.

A one-ounce copper trace of 0.25mm in length and 0.6mm wide has an impedance of approximately 193μΩ.  If this layout were to be used with an 8 milliohm shunt and 10 Amps flowing through the circuit, the 10 amps would create an 80mV drop across the resistor, and an additional 1.93mV drop across the trace, adding almost two and a half percent error to the measurement!

# Rule 3 – Follow the resistor maker's guidelines



Specialty resistors often have manufacturer recommendations.  In this case, the recommendations may be that there are large pads for the high current path and small pads for the Kelvin connected sense traces.

The bulk of the current flows through the trimmed part of the resistor and the kelvin connections are free to be measured with little interference from the load.

Landing pads guidelines are often found in the data sheets for these resistors, so be sure to follow them if you use a specialty resistor.

**To find more current sense amplifier technical resources and search products, visit ti.com/currentsense**

That concludes this video - thank you for watching! Please try the quiz to check your understanding of the content.

For more information and videos on current sense amplifiers please visit ti.com/currentsense.