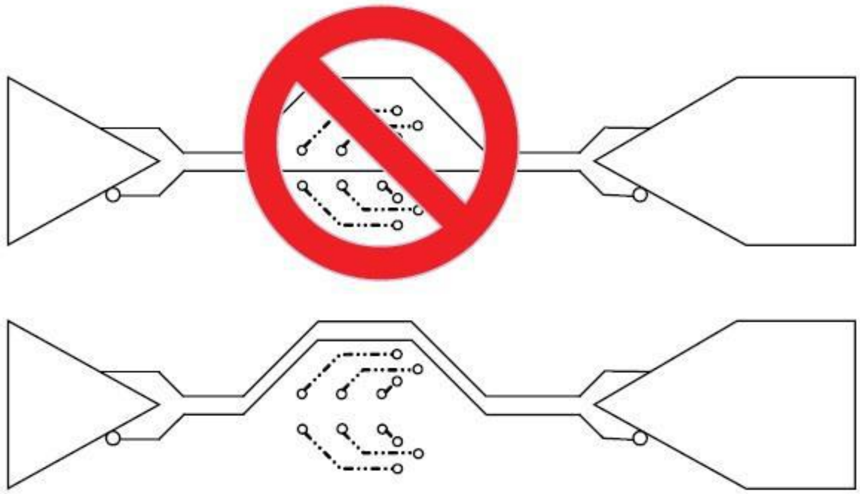
## A few words about design with respect to noise


Perhaps the biggest challenge in amplifying a low level analog signal coming from a sensor is managing noise and radio frequency (or electromagnetic) interferences. Noise can be easily intensified based on many factors such as length, shape and material of traces, connections, components used, location, temperature, etc. Such disturbances can appear in terms of a dc offset voltage or a train of pulses throwing the entire measurement process out of accuracy. Careful attention has been paid to each of those factors in designing the Tukoli Sensor Amplifier.

Tukoli Sensor Amplifier incorporates a low pass filter network at the input of the amplifier to deal with noise. This filter network has been designed through a lengthy process of experimenting and analysis. Aside from the quality of the components making up this filter network, it should be mentioned that the shape and length of traces/wires making a filter network located at the input of the amplifier is also very critical to managing noise and RF interferences. A typical rule of thumb is that the shorter the overall distance between the signal source (in this case the transducer's output differential signal leads) and the amplifier the better. The reason for that is the longer the traces carrying the output signal from the pressure transducer, the more opportunity they have, to pick up noise and interferences before they reach the amplifier. It is for that reason too that surface mount components were chosen as opposed to through hole components which have long leads.

Another point that was considered is that If there are differential signal traces that are travelling together, say the positive and negative signal traces from the sensor output signal through the filtering network, it is better the two traces follow the same shape and have the same length. Say for example there is a resistor on the way of one of the signal traces, and that trace has to go around the resistor in a 45° angle. It is better for the other signal trace to also take a 45° turn even if there is nothing obstructing it. This is to keep any delay equal in both traces. This is shown in the figure below:

## Routing Differential Traces



It is also good practice to keep adjacent differential signal traces close together, and away from traces carrying power to minimize interferences. Another tip is to avoid 90° angles in traces and instead to use chamfers or 45° angles whenever the traces must change direction.

The choice of resistor and capacitor values depends on the desired trade-off between noise, input impedance at high frequencies, CMRR, signal bandwidth, and RFI immunity. An RC network limits both the differential and common-mode bandwidth, as shown in the following equations:

$$FilterFrequency_{DIFF} = \frac{1}{2\pi R(2C_D + C_C)}$$

$$FilterFrequency_{CM} = \frac{1}{2\pi R C_C}$$

Where $C_D \geq 10C_C$.

CD affects the differential signal, and CC affects the common mode signal. A mismatch between R × CC at the positive input and R × CC at the negative input degrades the CMRR of the amplifier. By using a value of CD that is one order of magnitude larger than CC, the effect of the mismatch is reduced and CMRR performance is improved near the cutoff frequencies.