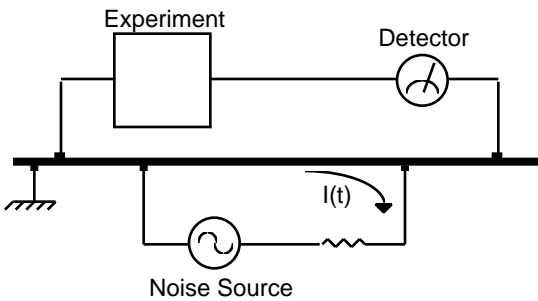


Cures for inductively coupled noise include:

- 1) Removing or turning off the interfering noise source.
- 2) Reduce the area of the pick-up loop by using twisted pairs or coaxial cables, or even twisting the 2 coaxial cables used in differential connections.
- 3) Using magnetic shielding to prevent the magnetic field from crossing the area of the experiment.
- 4) Measuring currents, not voltages, from high impedance detectors.

Resistive coupling or ground loops

Currents flowing through the ground connections can give rise to noise voltages. This is especially a



problem with reference frequency ground currents. In this illustration, the detector is measuring the signal relative to a ground far from the rest of the experiment. The experiment senses the detector signal plus the voltage due to the noise source's ground return current passing through the finite resistance of the ground between the experiment and the detector. The detector and the experiment are grounded at different places which, in this case, are at different potentials.

Cures for ground loop problems include:

- 1) Grounding everything to the same physical point.
- 2) Using a heavy ground bus to reduce the resistance of ground connections.
- 3) Removing sources of large ground currents from the ground bus used for small signals.

Microphonics

Not all sources of noise are electrical in origin. Mechanical noise can be translated into electrical noise by microphonic effects. Physical changes in the experiment or cables (due to vibrations for example) can result in electrical noise over the entire frequency range of the lock-in.

For example, consider a coaxial cable connecting a detector to a lock-in. The capacitance of the cable is a function of its geometry. Mechanical vibrations in the cable translate into a capacitance that varies in time, typically at the vibration frequency. Since the cable is governed by $Q=CV$,

$$C \frac{dV}{dt} + V \frac{dC}{dt} = \frac{dQ}{dt} = i$$

taking the derivative, we have

Mechanical vibrations in the cable which cause a dC/dt will give rise to a current in the cable. This current affects the detector and the measured signal.

Some ways to minimize microphonic signals are:

- 1) Eliminate mechanical vibrations near the experiment.
- 2) Tie down cables carrying sensitive signals so they do not move.
- 3) Use a low noise cable that is designed to reduce microphonic effects.

Thermocouple effects

The emf created by junctions between dissimilar metals can give rise to many microvolts of slowly varying potentials. This source of noise is typically at very low frequency since the temperature of the detector and experiment generally changes slowly. This effect is large on the scale of many detector outputs and can be a problem for low frequency measurements, especially in the mHz range.

Some ways to minimize thermocouple effects are:

- 1) Hold the temperature of the experiment or detector constant.
- 2) Use a compensation junction, i.e. a second junction in reverse polarity which generates an emf to cancel the thermal potential of the first junction. This second junction should be held at the same temperature as the first junction.