EXTERNAL NOISE SOURCES

In addition to the intrinsic noise sources discussed in the previously, there are a variety of external noise sources within the laboratory.

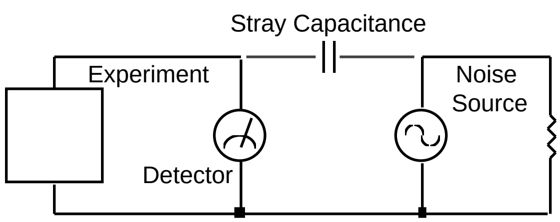
Most of these noise sources are asynchronous, i.e. they are not related to the reference and do not occur at the reference frequency or its harmonics. Examples include lighting fixtures, motors, cooling units, radios, computer screens, etc. These noise sources affect the measurement by increasing the required dynamic reserve or lengthening the time constant.

Some noise sources, however, are related to the reference and, if picked up in the signal, will add or subtract from the actual signal and cause errors in the measurement. Typical sources of synchronous noise are ground loops between the experiment, detector and lock-in, and electronic pick up from the reference oscillator or experimental apparatus.

Many of these noise sources can be minimized with good laboratory practice and experiment design. There are several ways in which noise sources are coupled into the signal path.

Capacitive coupling

An AC voltage from a nearby piece of apparatus can couple to a detector via a stray capacitance. Although C_{stray} may be very small, the coupled noise may still be larger than a weak experimental signal. This is especially damaging if the coupled noise is synchronous (at the reference frequency).



We can estimate the noise current caused by a stray capacitance by,

$$i = C_{stray} \frac{dV}{dt} = \omega C_{stray} V_{noise}$$

where ω is 2π times the noise frequency, V_{noise} is the noise amplitude, and C_{stray} is the stray capacitance.

For example, if the noise source is a power circuit, then f = 60 Hz and V_{noise} = 120 V. C_{stray} can be estimated using a parallel plate equivalent capacitor. If the capacitance is roughly an area of 1 cm^2 at a separated by 10 cm, then C_{stray} is 0.009 pF. The resulting noise current will be 400 pA (at 60 Hz). This small noise current can be thousands of times larger than the signal current. If the noise source is at a higher frequency, the coupled noise will be even greater.

If the noise source is at the reference frequency, then the problem is much worse. The lock-in rejects noise at other frequencies, but pick-up at the reference frequency appears as signal!

Cures for capacitive noise coupling include:

1) Removing or turning off the noise source.

2) Keeping the noise source far from the experiment (reducing C_{stray}). Do not bring the signal cables close to the noise source.

3) Designing the experiment to measure voltages with low impedance (noise current generates very little voltage).

4) Installing capacitive shielding by placing both the experiment and detector in a metal box.

Inductive coupling

An AC current in a nearby piece of apparatus can couple to the experiment via a magnetic field. A changing current in a nearby circuit gives rise to a changing magnetic field which induces an emf ($d\O_B/dt$) in the loop connecting the detector to the experiment. This is like a transformer with the experiment-detector loop as the secondary winding.