Lecture 8
Interference reduction

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Physics 198/250

External Noise

The major sources of external noise are electrical interference and inadequate grounds.

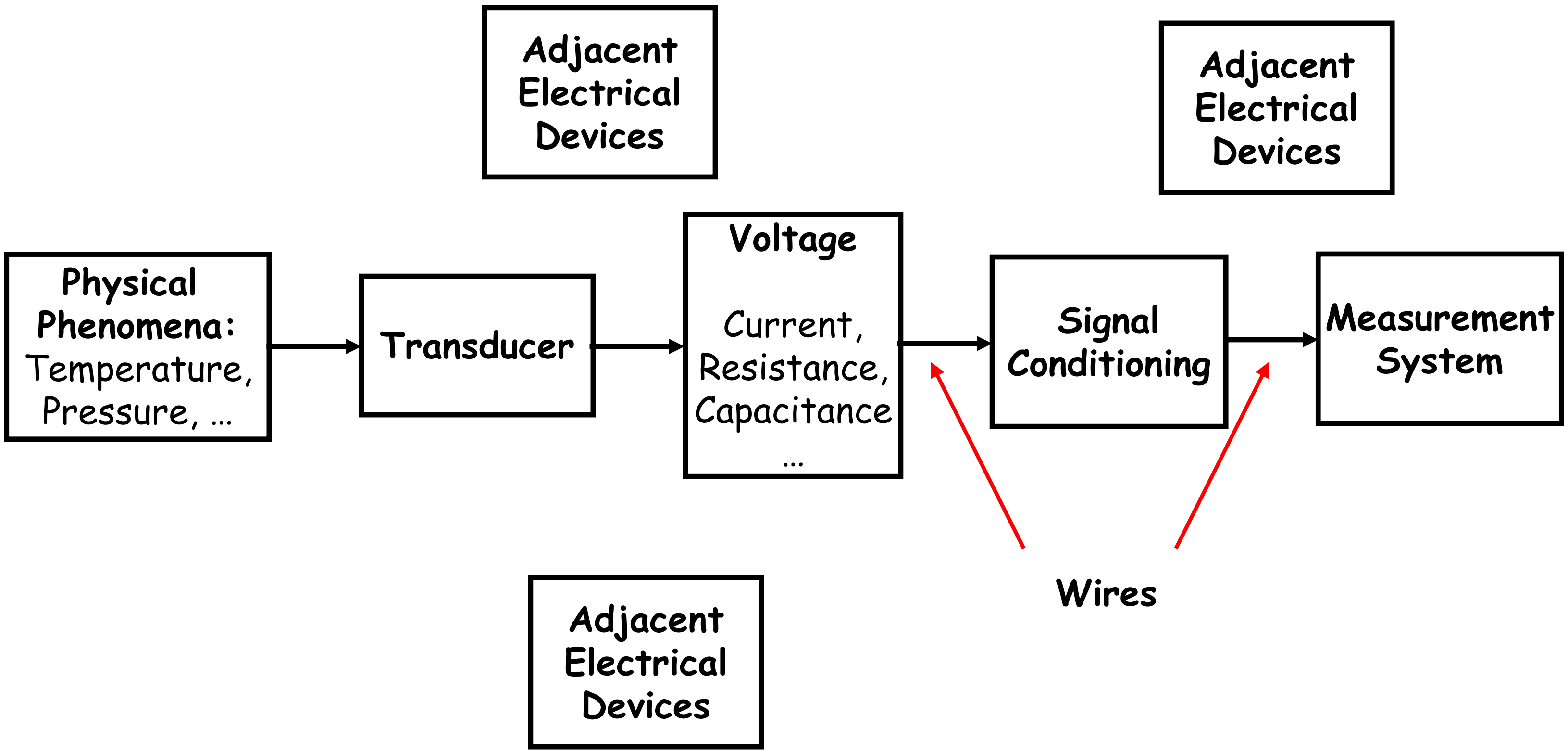
- Electrical interference is always at 60 Hz (power circuits) and harmonics or high frequency communication sources (radio and TV) or high-speed switching (digital electronics, dc-dc converters).
- Inadequate grounds will occur if one use a common ground for both digital circuits and power lines.

Ground systems

Low level analog grounds should be kept separate from digital grounds

- Coupling and ground loops between digital and analog electronics can create interference.
- Sharp transitions in the digital waveforms induce high frequency currents in the ground system, and they will couple to low-level circuits unless the grounds are kept separate.

Measurement System and Noise Source



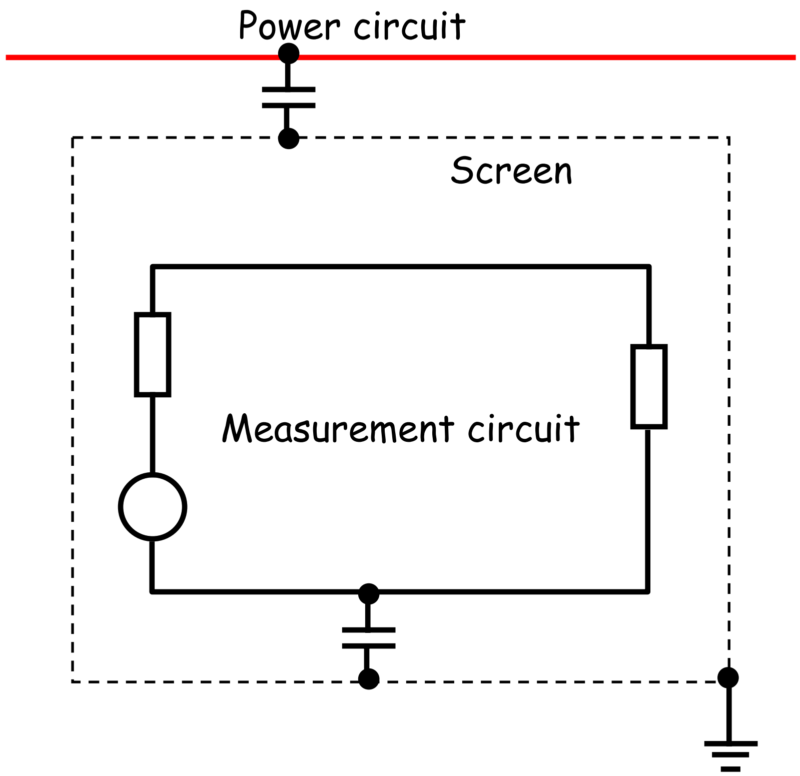
Noise Reduction using Physical Separation

Since mutual inductance and coupling capacitances between measurement system and power circuits are inversely proportional to the distance between them, the distance should be as large as possible.

Noise Reduction using Electrostatic Screening and Shielding

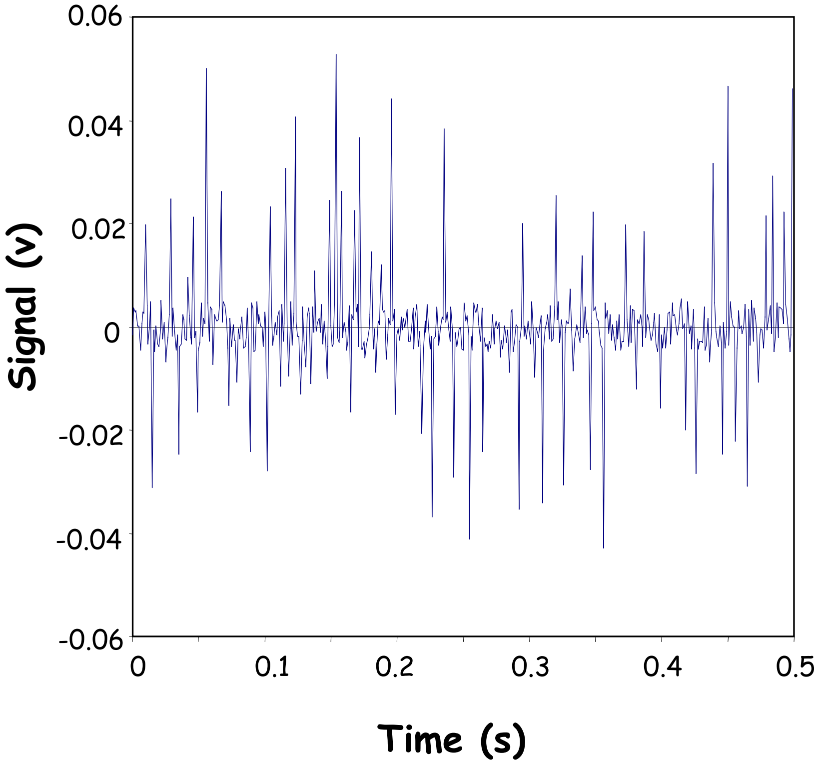
The best method of avoiding the problem of capacitive coupling to a power circuit is to enclose the entire measurement circuit in a grounded metal screen or shield. "Faraday cage."

Make no direct link between power circuit and measurement circuit.

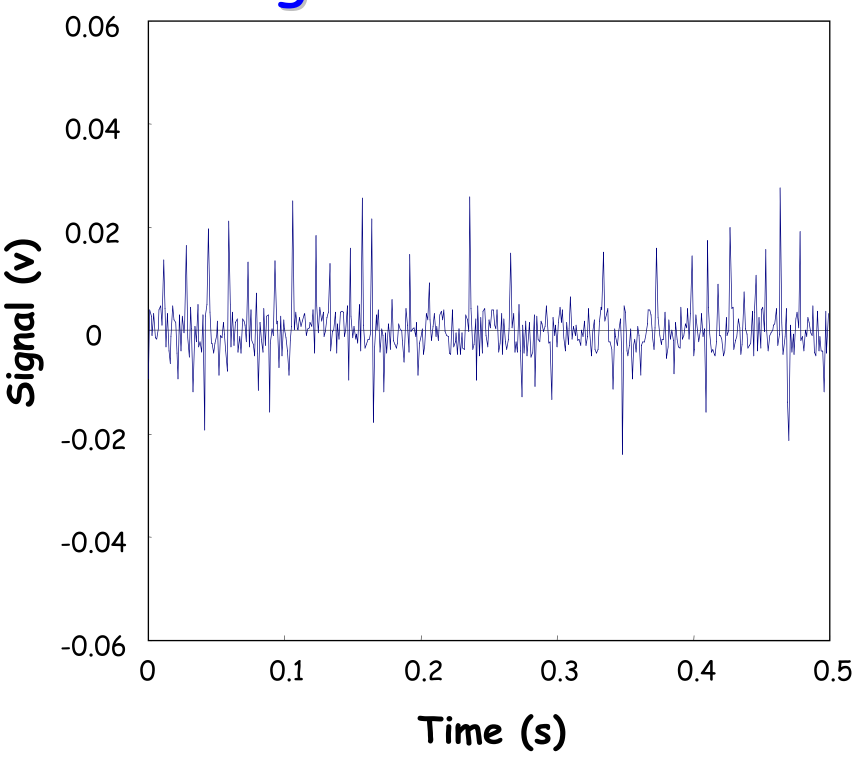


Noise Reduction using Shielded Wires

With Unshielded Wires

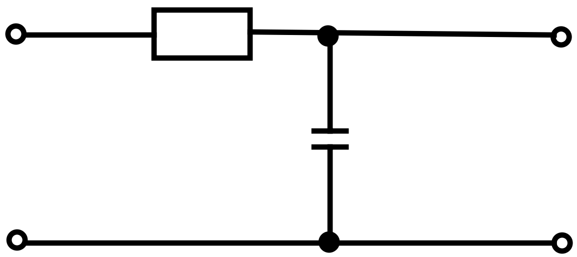


Using Shielded Wires

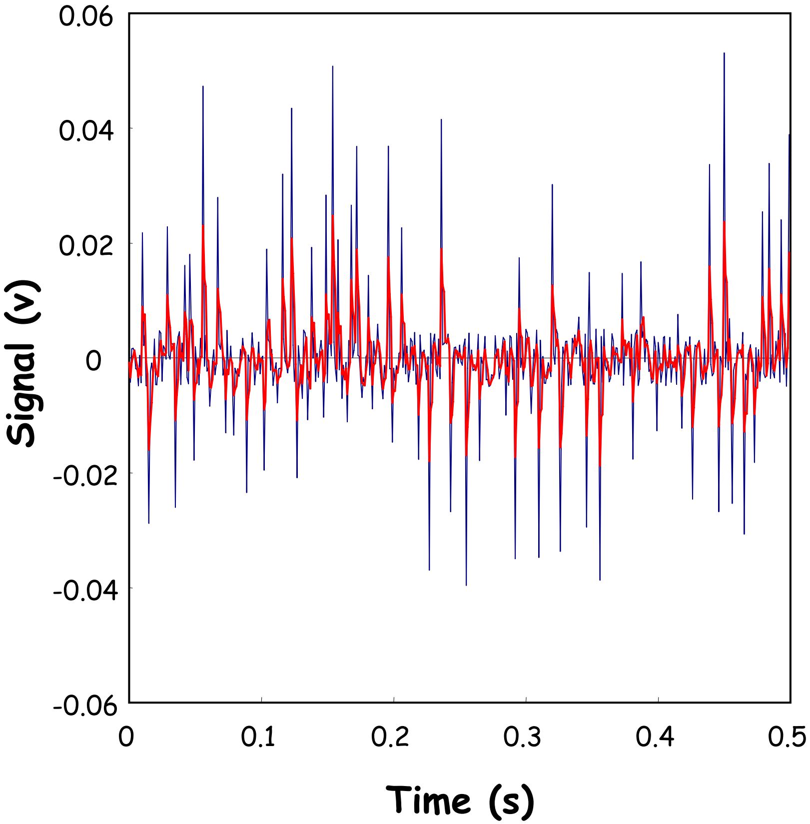


Noise Reduction using Analog Filter

An analog filter is a circuit element that attenuates an incoming signal according to its frequency. Depends on the design of an analog filter, we can attenuate either high frequency or low frequency or a range of frequencies.



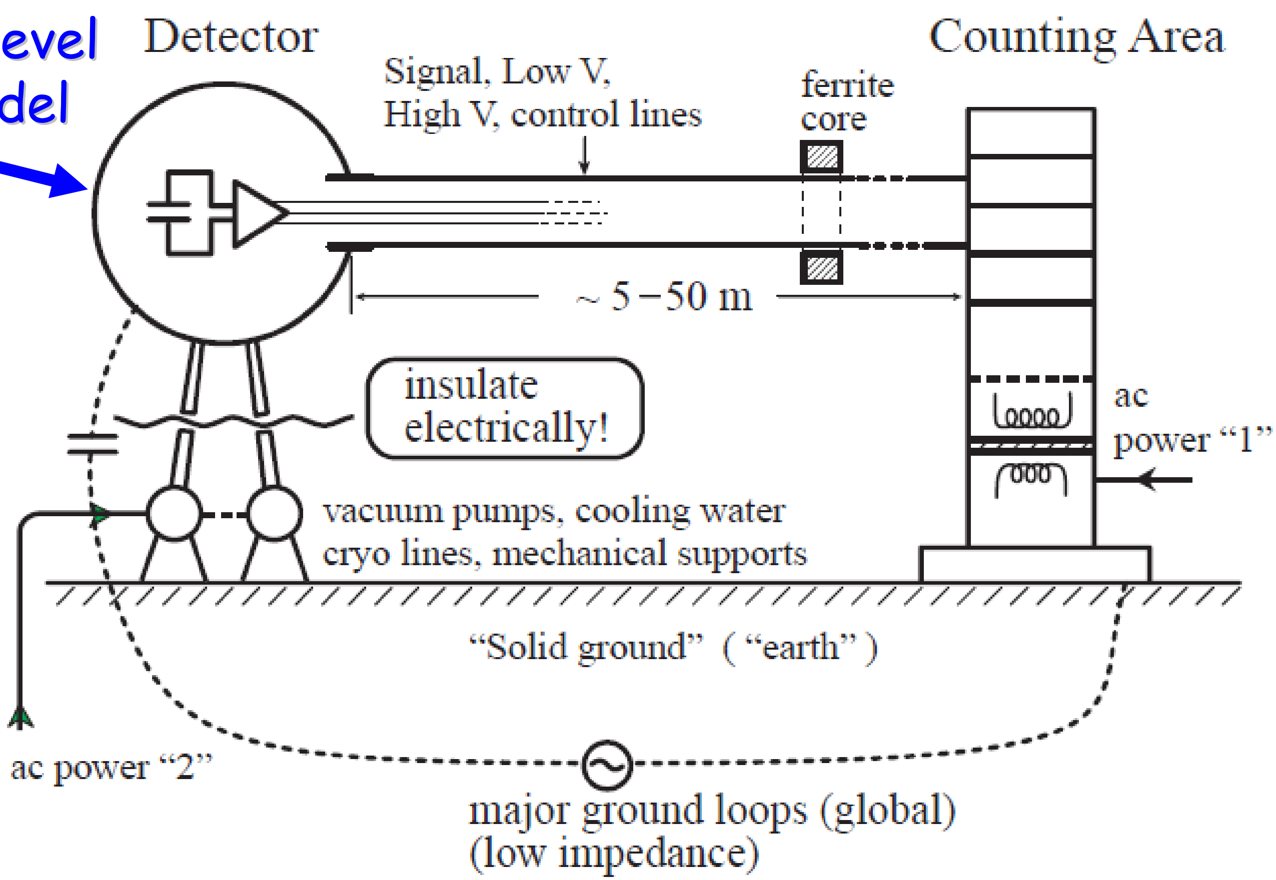
Noise Reduction using Filter



A last resort is to use either an analog filter and/or a digital filter to reduce the noise level of the data.

Avoid Ground Loops

Use common low-level Ground: tree model

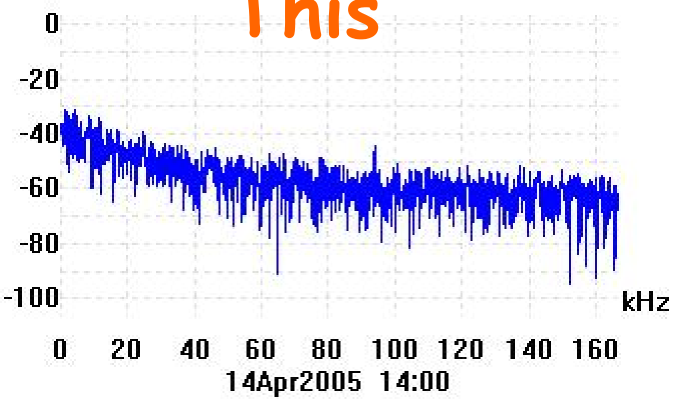


Sanity check

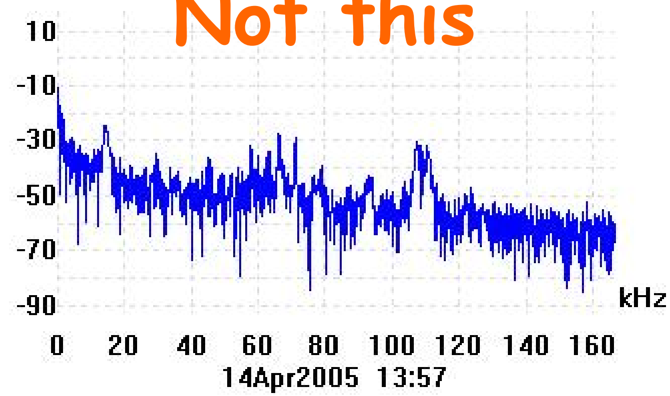
Check directly to make sure that interference is absent from low-level analog signal circuits.

- Look at the analog signal output with a battery operated spectrum analyzer. You should just see noise.

This



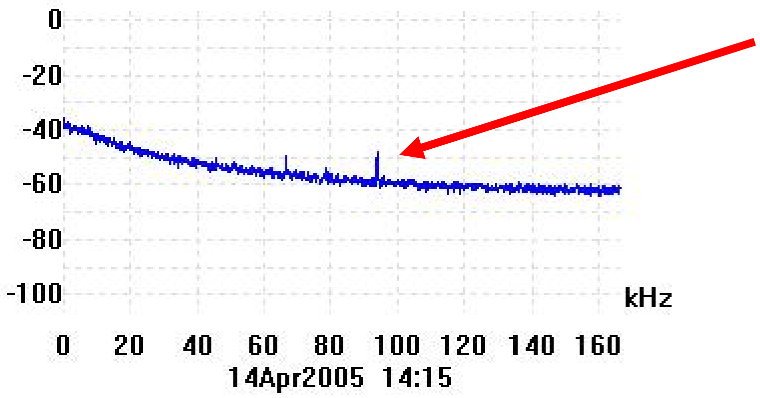
Not this



Average the spectrum

The ultimate search tool

- Do not average so long that you cannot see the time behavior of the interference. Often it is the time signature, combined with experimentation, that pins down the culprit.



This interference at 94 KHz is 50dB down, i.e. 10 ppm of the analog signal. One can then try to eliminate it, or chop the signal at some very different frequency.

Hunting down the source

You will have to find out which candidate source is the one causing the interference. If spectrum analysis fails to isolate the source and you think it is in the digital electronics:

- Put isolated x10 probe from a battery operated scope on key analog data lines. [i.e. avoid introducing your own ground loops in the test setup.]
- Sync the scope to the digital pulses, one by one (from the digital circuits.)
- Search for the source of feed-through of digital transitions. Then deal with the culprit.

Reduce sensitivity to interference

Be alert: look for non-stationarity in your data!

Use good isolation techniques:

- Avoid ground loops
- Use differential inputs
- Test for common-mode problems
- Test for and minimize pick-up