Electrical noise + Interference.

Goal of experiments is to pick out signals of interest from extraneous (noise) signals.

Sources of noise and interference can be varied and should ideally be analyzed and the effect determined. This can be tedious and open ended.

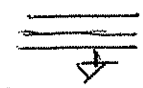
Sources of interference + noise can be external, or internal to the circuit used.

Some sources of external interference.

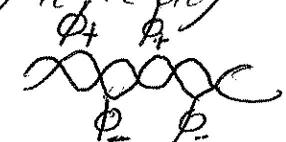
→ Power lines, transformers + motors, radio station

Can couple to circuit of interest

(a) Electrostatically (capacitively). → (High impedance act like current sources).

Reduce by shielding → Faraday cage.
Coax.

twisted wire. 

b) Magnetic coupling
Loops of wire, inductance magnetically couple signals

→ reduce → Twisted wire 

$\phi \to 0$.

→ High permeability shield → iron, mumetal

Electromagnetic Coupling.

Circuit elements act like antennas to pick up rf signals &

reduce by redesigning layout.

Ground loops

→ Supply + ground lines have non zero resistance If there are varying large current, then the ground lines vary in voltage and this can feed into your circuit.

reduce by using sturdy supply + ground line

Also helps to tie grounds of different circuits to the same ground point

Intrinsic noise in circuits

From ~~En~~ statistical mechanics → fluctuation-dissipation theorem.

Resistance → Voltage fluctuations.

(A) $P = 4kTB$

$V_{noise}(rms) = (4kTRB)^{1/2} = 1.3 \times 10^{-10} R^{1/2}\, V/\sqrt{Hz}$

Called Johnson/Nyquist/white noise.

Reduce – lower T, Bandpass filter, Signal average.

(B) Current (Shot) noise.

Uncorrelated carriers → poison distribution

$Q +/- \sqrt{Q}$

$I_{noise}(rms) = (2q I_{DC} B)^{1/2} \quad (q = 1.6 \times 10^{-19} C)$

$1A \quad \left(\frac{I_n}{I}\right) = 57 \times 10^{-9}$

$1 pA \quad \frac{I_n}{I_A} = 5.7 \times 10^{-9}$

Uncorrelated carriers (PMT, diodes).

→ Signal average.

$\frac{1}{f}$ noise (flicker/pink noise)

Component value fluctuates. It is device dependent.

Equal power in ~~equal~~ decades.

→ effect larger at lower frequencies

Mechanical noise coupling.

Vibration (microphonics) - couple signals capacitively, inductively or piezo electrically.

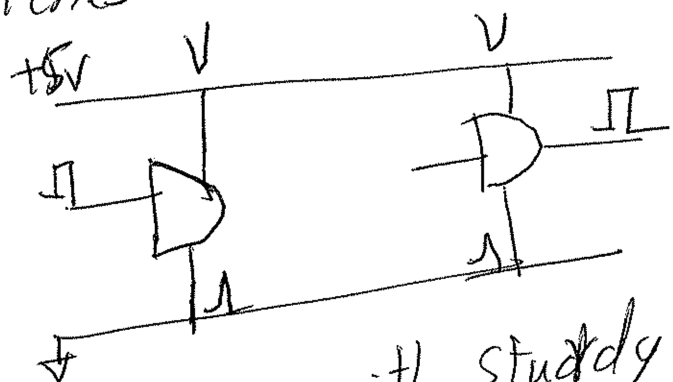
To reduce $\frac{1}{f}$ + microphonics work at frequencies above ~100Hz.

Design measurement to be peridic at ~100HZ + have a good band pass filter to reduce low frequency signals → lock in detection.

Digital signal interference.

Digital signal switch currents fast ~1ns. between logic levels.

If ground + supply lines are weak then the resistance of these line put in signal glitches.



Reduce with sturdy grounds

Capacitively bypass Vcc to ground every few chips

→ Separate analog + digital grounds

High frequency signal.

Impedance mismatch → reflection.

Reduce by designing ~~circuits w~~ lines with a characteristic impedance + terminate the lines with the characteristic impedance. → eliminates reflections