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Lecture 40

Noise in op-amps

Recall Johnson noise

$$(v_n)_{rms} = \sqrt{4 k_B T R B}$$

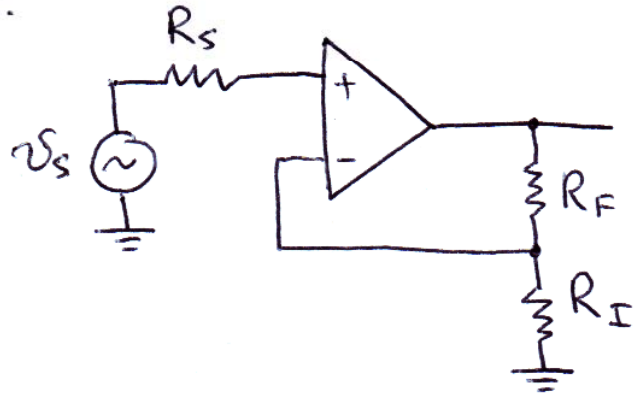
Noise terms:

—

—

—

Ex.



E.g. LF356

$e_n \sim 12\,nV/\sqrt{Hz}$

$i_n^{\pm} \sim 0.01\,pA/\sqrt{Hz}$

$R_I \simeq 1k\Omega$

$R_F = 100k\Omega$

$R_S \simeq 5k\Omega$

II Interference

- noise due to sources _____ to the circuit
-

Sources

-

-
-
-
-

Coupling mechanisms

① Mechanical

-

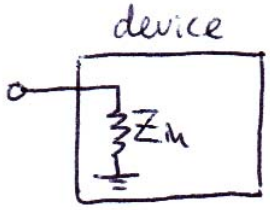
-

-

-

② Capacitive coupling

- any two conductors connected by _____ have capacitance b/w them



To reduce

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Lecture 41

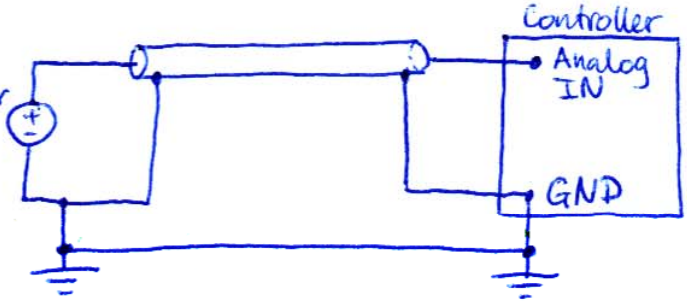
(3) Magnetic coupling

- time varying B-field induces voltage _____
- low freq. B-field is <u>not</u> easily shielded by metals

To reduce

- avoid

Ex.



- use

- use magnetic shielding :

- use isolation transformers
  opto-isolators

(4) RF coupling

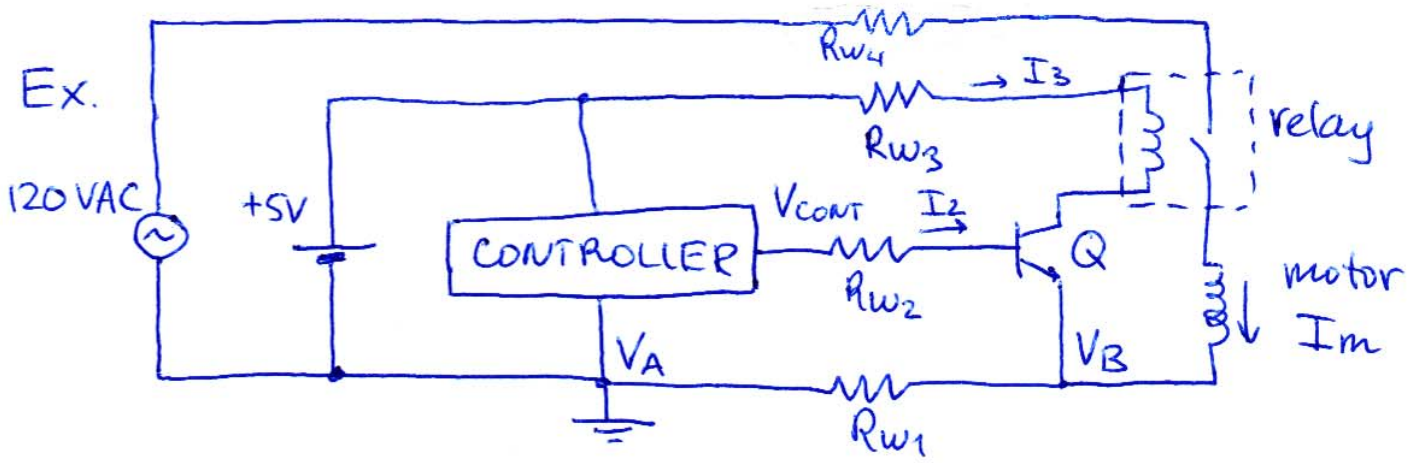
- wire leads, circuit parts can act as resonant pickups

To reduce

- use shielding
- keep short leads

(5) Resistive coupling

- wires ≠ equipotentials, have finite resistance
  ⇒ currents flowing thru ground lines can generate



To reduce

- use low resistance ground wires (copper busbars in extreme cases)
- separate grounds for _____ level circuit parts

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Lecture 42

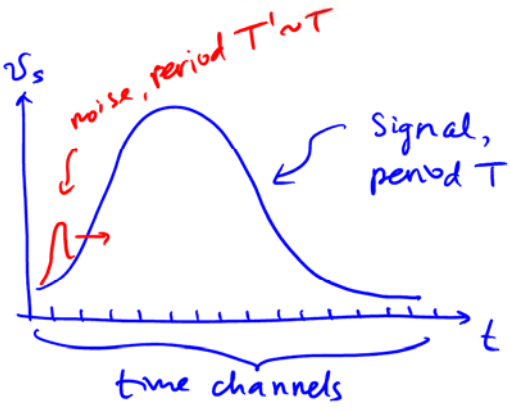
Detecting signal buried in noise

For poor S/N signal, recovery is often possible

⇒ SNR can be made very large

signal averaging – example of _____

Ex.



$$SNR_{dB} = 10 \log_{10}\left(\frac{P_s}{P_n}\right)$$

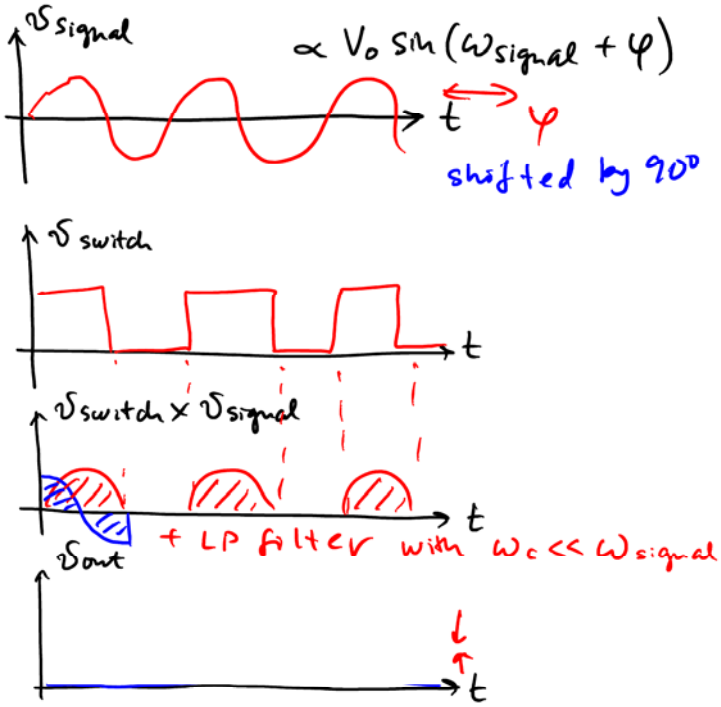
SNR increases 3dB for each _____

Lock-in amplification

- most signals can be made repetitive

- if signal can be addl. made periodic, can use lock-in amp

Phase sensitive detector:

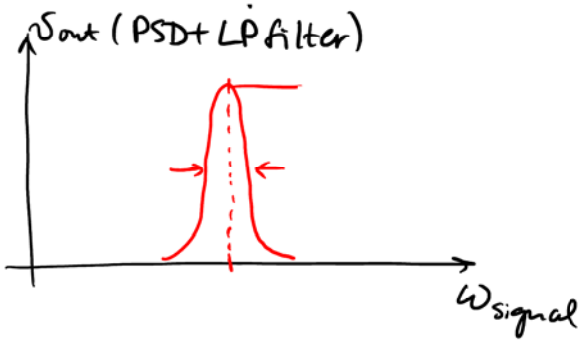


Lock-in amp

1) system response signal of interest V_0

2) PSD:

3) LP filter after PSD



Application Example

you are measuring a very weak signal, e.g. fluorescence