Lab #2: Working with noisy sensor inputs

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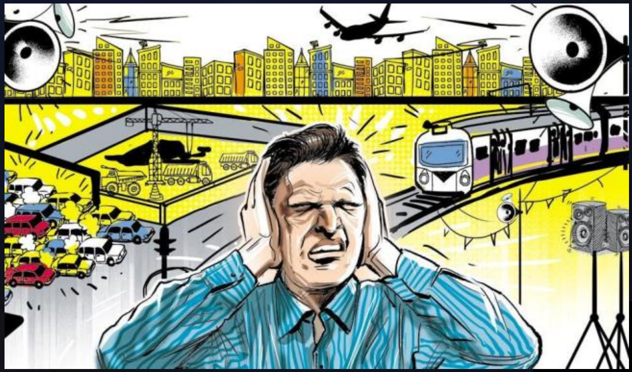
Motivation

- Real-world measurements are ***always*** noisy
  - physical device limitations
    - bias, drift, calibration error, aging
  - circuit effects
    - temperature-dependence, saturation, slew
  - noise and interference
    - thermal noise, extraneous signal sources
  - digitization
    - quantization error, aliasing

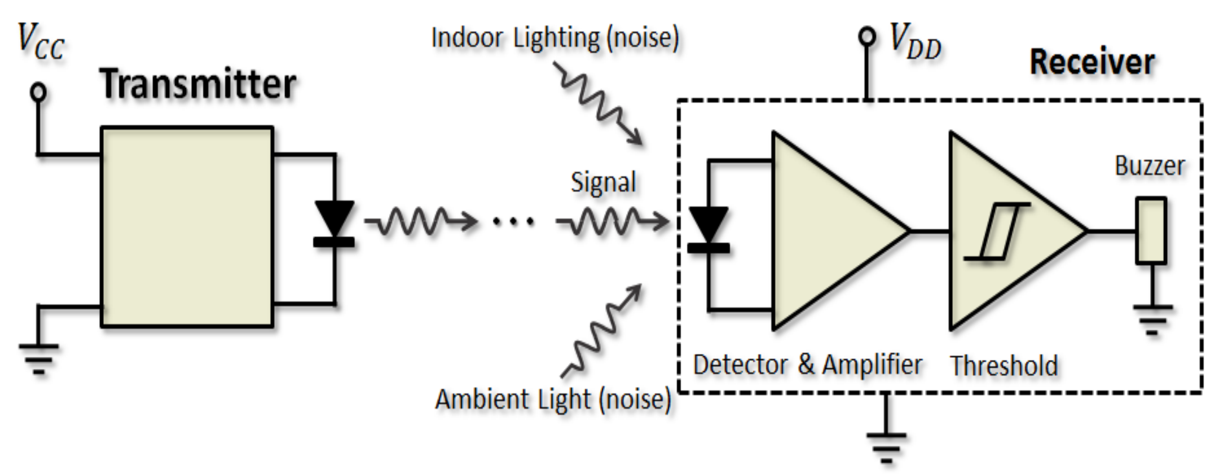


Design for Uncertainty

- Highly noisy sensors common in senior design
  - proximity detectors, wireless signal strength, accelerometers are all notoriously noisy
- Naïve system design that assumes perfect inputs cannot be trusted
  - e.g. noisy proximity sensors trigger false alarms
  - The Boy Who Cried Wolf problem
    - phenomenon of “alarm fatigue” in hospitals

The "Electric Eye"

Light beam interrupter safety system



Example Application: a garage door opener

“The revised standard requires that residential garage door openers contain one of the following:
-External entrapment protection device, such as an "electric eye" which "sees" an object obstructing the door [...]"

- 1993 regulation by the Federal Consumer Product Safety Commission (CPSC)

Example Application: industrial safety system

"Light Curtain" in an industrial setting

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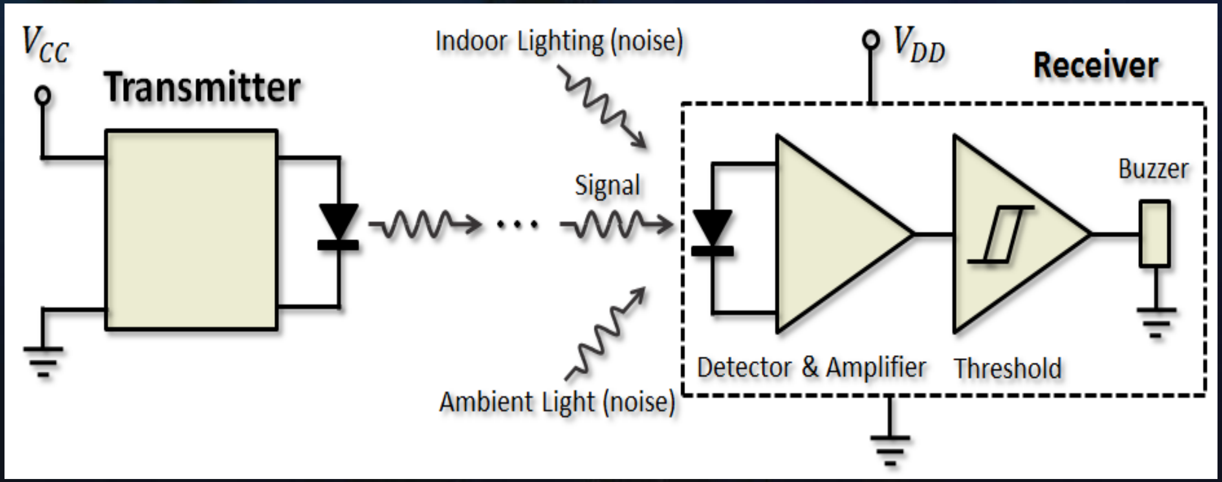
Lab #2: design a robust electric eye

- a variety of ambient lighting conditions
  - sunlight, indoor lighting, computer monitors, phone screens
- must separate “signal” from “noise”



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Design Options - 1

- Optical filtering. Infrared LED at Tx; photodiode sensitive to IR, but not visible light

- Electronic filtering. Integrate photodetector output using a capacitative load

Design Options - 2

- Software filtering. Digitize photodetector output and integrate numerically
- Matched filter. A more sophisticated variant of the integrator.

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Lab Requirements

- You will be provided with a prototype Tx and Rx. Prototype works well in low light, but fails when exposed to an incadescent lightbulb

- Your receiver must work at least as well as the prototype receiver, but should also work with a 100 W incandescent lightbulb. In general, the receiver should be designed to work with as many different ambient light sources as possible e.g. fluorescent lamps, and even when exposed to infrared LEDs other than the prototype Tx.

- **SMS alert feature**. Your receiver must send text alerts when a breach is detected. The format for the SMS alert is specified in the lab manual on ICON.

Requirements (contd)

- A slight performance degradation (e.g. a slightly increased latency) is acceptable
- You are not allowed to modify the transmitter in any way. It is ok to use the existing receiver prototype as a starting point and modify it
  - or start from scratch
- Your receiver should not have an abnormally large size or weight or other physical characteristics
  - you can use an external PC e.g. to generate the SMS alerts, but need to take into consideration the physical/space constraints

Additional Information

- Schematics for the prototype transmitter and receiver will be available on ICON
  - you can use these to build a replica of the transmitter for testing

- **<u>HOWEVER</u>** the prototype transmitter may have subtle differences from the schematic
  - e.g. reported component values are slightly off
  - (to be clear: the schematic is not deliberately inaccurate)

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Test your assumptions!

- You are expected to design and conduct experiments to confirm your understanding of the behavior of the transmitter
  - the design of these experiments and the resulting observations must go into your lab report

- your receiver must be compatible with the prototype transmitter as it exists
  - not simply with the schematic

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