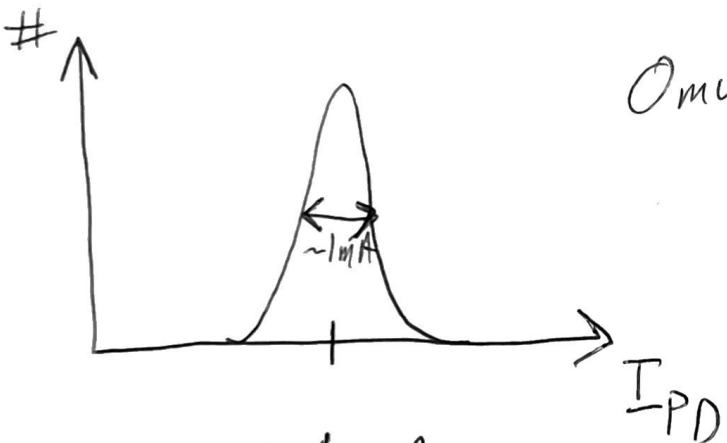
LED — PD

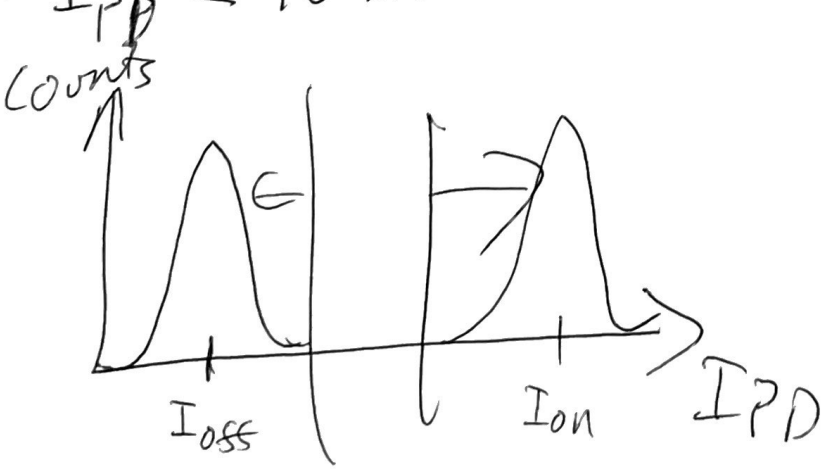
turn LED on & off 1000 x / sec

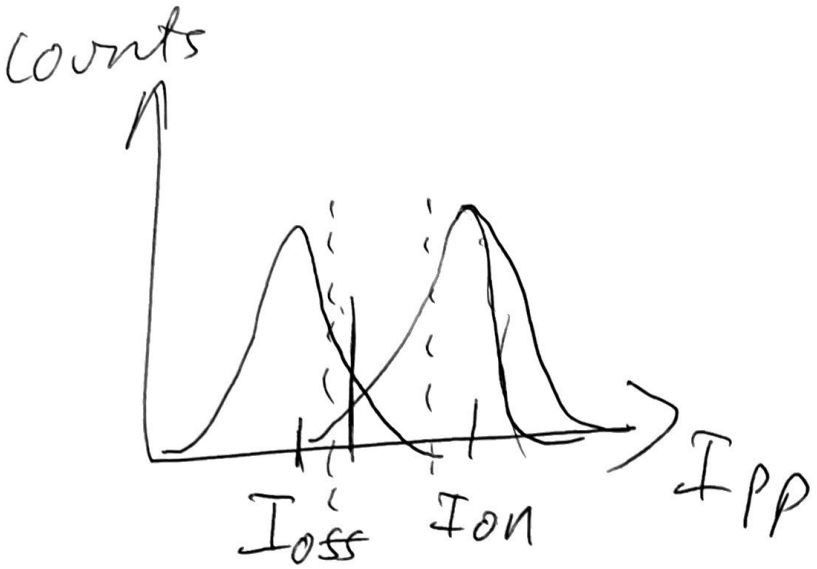


$0mw < P_{out} \leq 100\ mW$

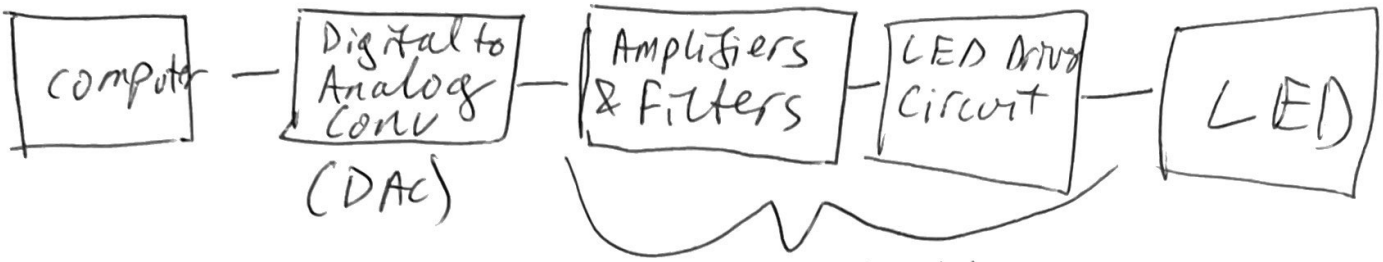
$R_{PD} = 0.1\ \frac{A}{W}$

OA $I_{PD} < 10\ mA$



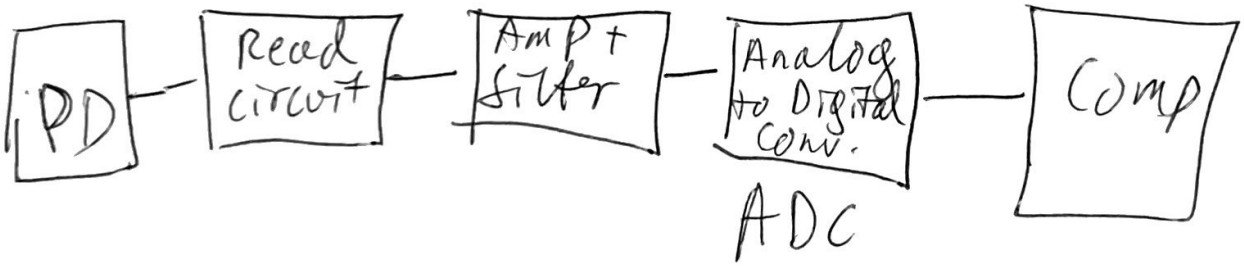

counts
Ioff
Ion
Ipp

Transmit ~~Detect~~



converts the output analog signal into voltage needed for LED

Receiver



Three Intrinsic Noise Sources

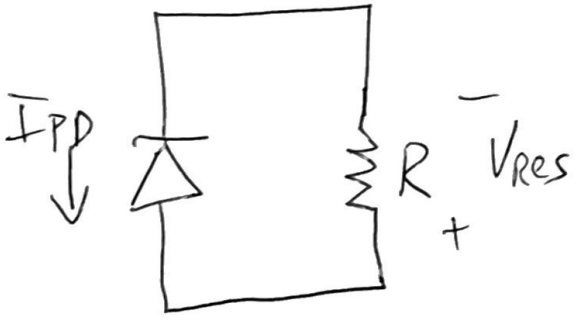
1. Thermal Noise
2. Flicker Noise
3. Shot Noise

① Thermal noise

$V_N^2 = 4 K_B T R (\Delta \nu)$ → "ν" not V

$V_N^2 = I_N^2 R^2 = 4 K_B T R (\Delta \nu)$

$I_N^2 = \frac{4 K_B T \Delta \nu}{R}$



Shine light on PD so I_1

$V_{Res} = I_1 R$

$V_{Res} \pm \sqrt{V_N} = V_{Res} \pm \sqrt{4 K_B T R \Delta \nu}$

② Shot Noise

$$i_N^2 = 2qI\Delta f$$

$q = 1.602 \times 10^{-19}\ C$

I = current

Δf = Bandwidth

③ Flicker Noise

$$\frac{1}{f^{\alpha}}$$

$f(t) = \sin((2\pi f)t)$

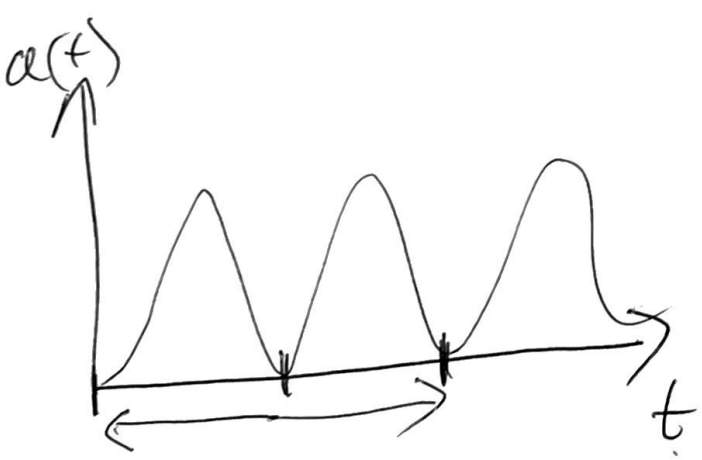
$0 \rightarrow 360^\circ \rightarrow 2\pi$

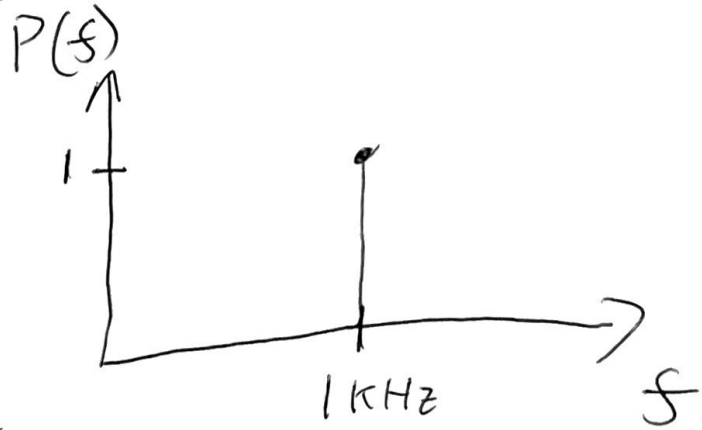
$f \rightarrow Hz - \frac{1}{s}$

$2\pi f = \omega = \frac{\text{radians}}{\text{sec}}$

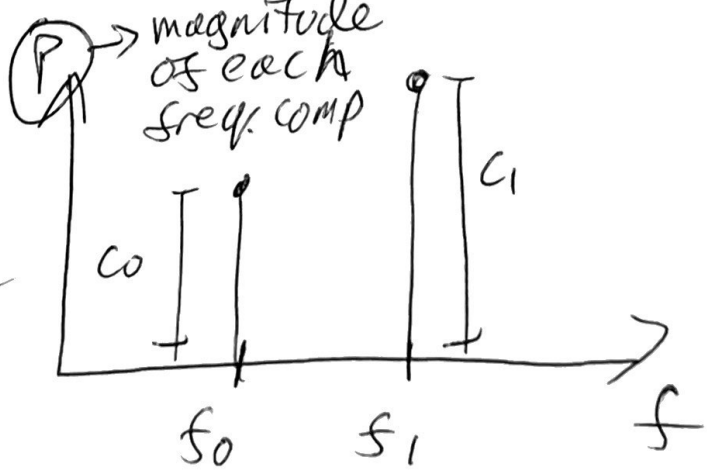
EXAMPLE

$a(t) = \sin(2\pi f_0 t)$ $\quad f_0 = 1000\ Hz$





$b(t) = c_0 \sin(2\pi f_0 t) + c_1 \sin(2\pi f_1 t)$



$V_{N1}^2 \Rightarrow$ Thermal noise voltage

$V_{N2}^2 \Rightarrow$ Shot noise voltage

$$V_{total}^2 = V_{N1}^2 + V_{N2}^2$$

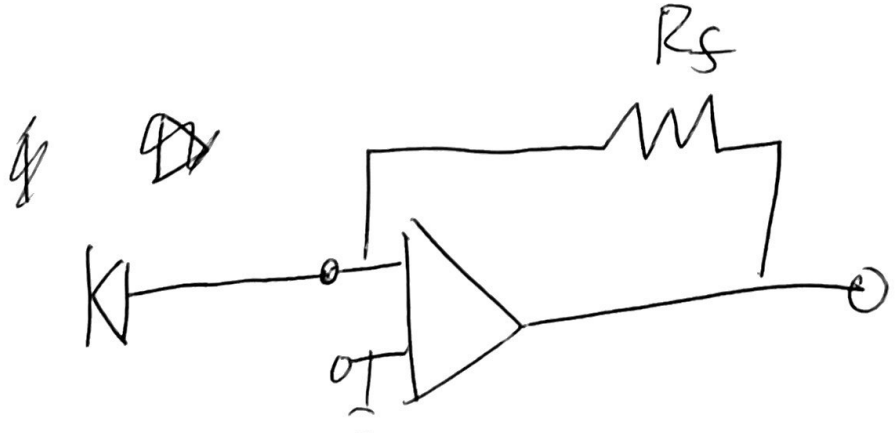
$$\Delta f = \Delta V$$

$$V_t = \sqrt{4 K_B T R \Delta f}$$

↑ thermal noise

$$I_{shot} = \sqrt{2 q I_{Ph} \Delta f}$$

↳ current in photodetector due to light signal



$$V_{shot} = R_f \sqrt{2 q I_{ph} \Delta f}$$

$$V_{Tot} = \sqrt{V_{shot}^2 + V_t^2}$$