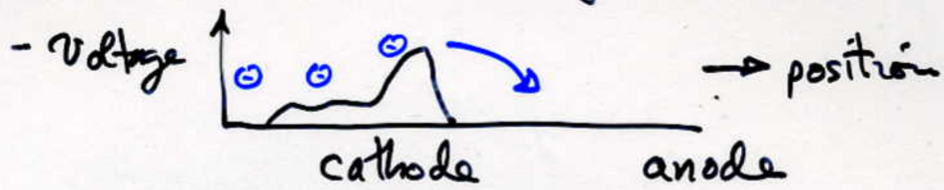
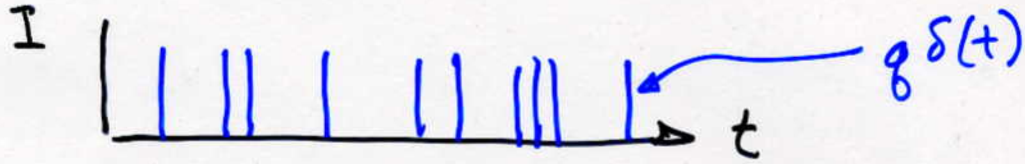
Shot noise

Charge is quantized.

Consider current through barrier:

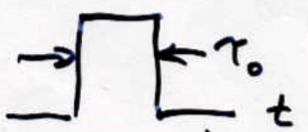


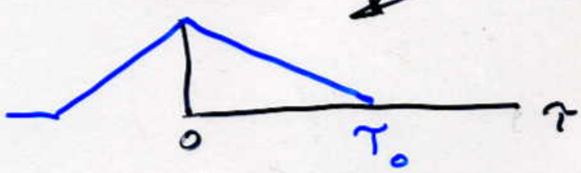


Auto correlation function for δ function spikes is $\overline{I(t)\, I(t+\tau)} = \delta(t)$

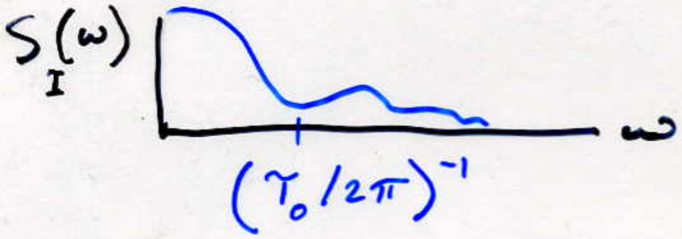
According to the WK theorem we should get white noise.

However, if the pulses have finite width τ_0, like charge transiting a diode, then the autocorrelation function looks like





WK theorem $\rightarrow$ $S_I(\omega) \sim \left[\dfrac{\sin \omega \tau_0 / 2}{\omega \tau_0 / 2} \right]^2$



per pulse

Poisson statistics for random events:

Given n events in time τ (note $\bar{n} \neq 0$)

$$\overline{(\Delta n)^2} = \bar{n}$$

Since electrons are charged, there is a current $I = \bar{n} e / \tau$

$$\therefore \overline{(\Delta I)^2} = \frac{\overline{(\Delta n)^2} e^2}{\tau^2} = \bar{n} e^2 / \tau^2$$

$$\text{or} \quad \overline{\Delta I^2} = e \bar{I} / \tau \equiv S_I(f) \, \Delta f_{eff}$$

Averaging over time τ → effective bandwidth $\frac{1}{2\tau}$

$$\Rightarrow \boxed{S_I(f) = 2 e \bar{I}} \qquad \text{SHOT NOISE}$$

Constant white noise up to frequency cutoff related to the pulse width τ_0.

Unlike Johnson noise, this is not thermal.

1 amp → 5.7 nA / kHz