ⓐ Shot Noise:

$$i_n = \sqrt{2qI_D\Delta f}$$

This noise occures due to quantum nature of Electron Flow through a Potential Barrier. Carriers exhibit average rate (DC value) of crossing, but indivisual carriers cross barrier as random events

In above equation I_D is the forward current in the device, and Δf is measurement bandwidth.

Clearly Shot noise $\propto \sqrt{I_D}$, but it is $\neq f(\text{Temp})$

In MOSFET, Subthreshold Currents exhibits Shot Noise.

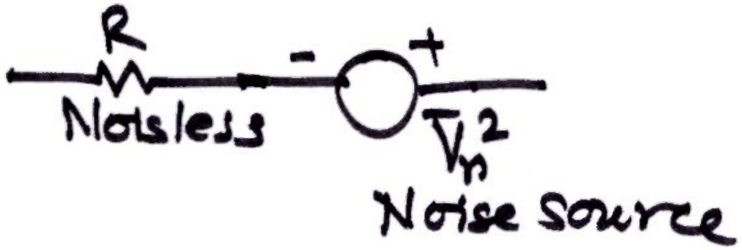
(b) Johnson Noise (Thermal Noise):

Random carrier motion (Drift, Diffusion) gives rms Noise power as

$$S_n(f) = \int_{f_1}^{f_2} kT\, df = kT\,\Delta f$$

$$\therefore S_n(f) \propto T \implies \text{Thermal Noise}$$

A resistor can be modeled as



spectral density

$$S_v(f) = kT\,\Delta f = \frac{\bar{V}_n^2}{R}$$

$$\text{or } \bar{V}_n^2 = kTR\,\Delta f$$

If V_n is expressed in rms value & $\Delta f = 1\text{Hz}$ then $\bar{V}_n^2 = 4kTR$

As $\overline{i_n}^2 = \frac{\overline{V_n}^2}{R^2}$ current noise source

$\therefore \quad \overline{i_n}^2 = \frac{4kT}{R} = 4kT.G \quad (G = \frac{1}{R})$

(c) 1/f Noise (Flicker Noise)

Due to number fulctuations occuring due to Defects, Contaminants and <u>Interface States</u>, one observe 1/f noise. Johnson invented it in 1923 is Vacuum Tubes. Exact nature is not very much known, but a low frequencies, the noise shows inverse proportion to frequency (1/f behavior), and hence called 1/f Noise