NOISE:

Noise is an unwanted and unpredictable signal which affects the signal. Noise generated in Photodiode is due to thermal variation and fluctuation of charge carriers when photon strike it. The fluctuation in generation of charge carriers is called shot noise. The Photodetector is generally required to detect very weak optical signal. Therefore it is necessary to design Photodetector with very good Signal to Noise (S/N) ratio.

The Signal to Noise ratio is given by:

$$\frac{S}{N} = \frac{\text{Signal Power from Photocurrent}}{\text{Photodetector noise Power} + \text{Amplifier noise Power}}$$

To have a high S/N ratio, the following condition should be fullfilled:

a) The Photodetector must have a high quantum efficiency to generate a large signal Power.

b) The Photodetector and amplifier noise should be kept as low as possible.

Following types of noise are associated in photodetector system.

1. Shot Noise (Quantum Noise)
2. Thermal (Johnson) Noise.
3. Dark current Noise
4. Surface Dark current Noise
5. Bulk Dark current Noise.
6. Statistical gain fluctuation (In Avalanche diode)

1. Shot Noise (Quantum Noise): In a photodiode the actual number of photon striking at a particular time is unknown and so it is a random variable. Hence no of electrons producing photocurrent will vary because of their random recombination and absorption. Deviation of the actual number of electrons from the average number is known as shot noise. It is denoted by i^2_{shot}. It is given by

$$i^2_{shot} = \sigma^2_{shot} = 2q I_p B_e M^2 F(M)$$

where;

B_e = Receiver Bandwidth

$F(M)$ = Figure of Merit (for pin photodiode it is unity).

2. Thermal Noise: Motion of electrons due to temperature occurs in a random way. Thus, the number of electrons flowing through a given circuit at any instant is a random Variable.

The deviation of an instantaneous number of electrons from their average value because of temperature change is called thermal Noise.

Thermal noise is often called Johnson noise after the Scientist who first found it experimentally and less often as Nyquist Noise after the scientist who developed its theory. It is given by

$$i_T^2 = \sigma_T^2 = \frac{4 K_B T B_e}{R_L}$$

Where; K_B = Boltzmann constant = 1.38×10^{-23}

T = Absolute Temperature

R = Resistance

The Noise can be reduced by using a load resistor which is large but still consistent with the receiver bandwith requirements

3. Dark Current Noise: When there is no optical Power incident on Photodiode, a small reverse leakage current still flows from device terminals. It gives random fluctuations about the average particle flow of the Photo current. It is called dark noise. It is given by

$$i_d^2 = 2eBI_d$$

Where,

e = electron charge

i_d = dark current

B = Bandwidth.

4. Surface dark current: The Surface dark current is also known as surface leakage current. It is dependent on Surface defects, cleanliness, bias voltage and Surface area. The mean square value of this surface dark current is given by:

$$i_{DS}^2 = \sigma_{DS}^2 = 2qI_L B_e$$

Where I_L = Surface lekage Current.