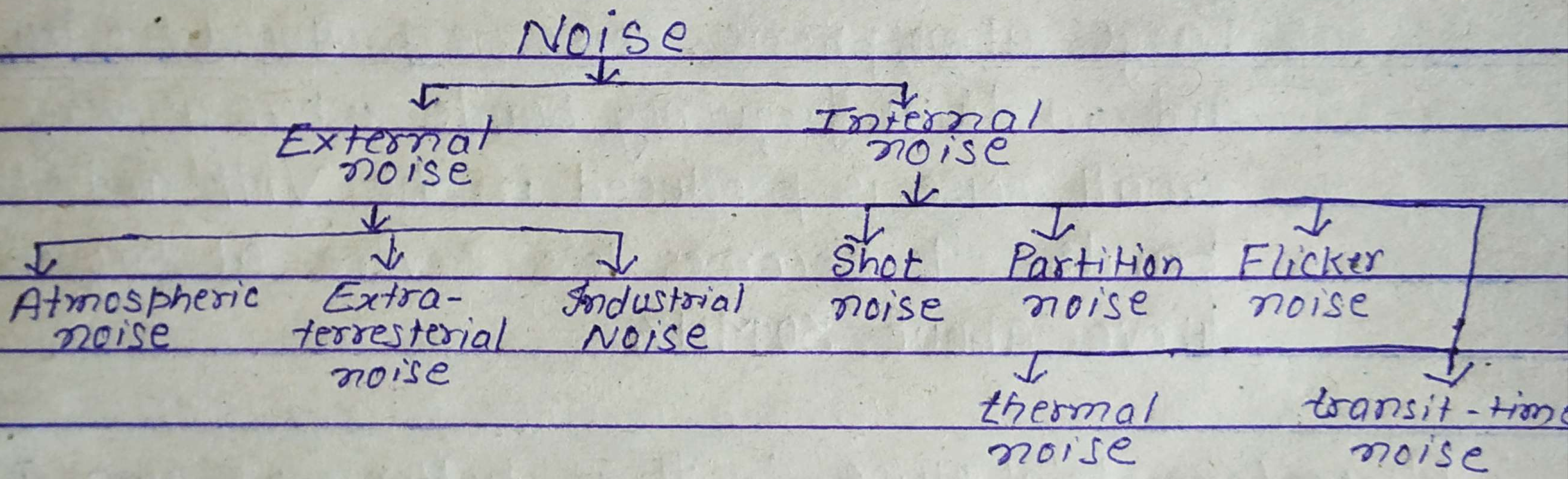
Noise

In electrical terms, noise may be defined as an unwanted form of energy which tend to interfere with the proper reception and reproduction of transmitted signals.

Classification of Noise
i> External Noise
ii> Internal Noise



External Noise :- It may be defined as that type of noise which is generated external to a communication system i.e whose source are external to the communication system.

It cannot be analysed quantitatoviely neither it can be controlled. Only way to reduce the effect of external noise, is to shift the communication system to other place or location which has comparatively smaller external noise.

Atmospheric noise :- It is ~~a~~ also called static, is produced by lightning discharge in thunder-storms and other natural electrical disturbances which occur in the atmosphere.

Atmospheric noise contains spurious radio signals which are distributed over a wide frequency range.

Large atmospheric noise is produced in low and medium frequency bands where as very small noise is produced in the VHF and UHF bands. It becomes less severe at frequencie above about 30 MHZ

Extraterrestrial Noise :- It is better ~~no~~ known as space noise. Solar noise and cosmic noise are its sub-classifications.

Solar noise is the electrical noise eminating from the Sun. The radiation of noise from the sun is due to the fact that sun is a big body at an extremely high temperature and it radiates electrical energy in the form of noise over a wide frequency spectrum including the frequency spectrum occupied by radio communication.

Industrial Noise :- Industrial noise or man-made noise is that type of noise which is produced by such sources as automobiles and aircraft ignition, electrical motors, switch gears and leakage from high voltage transmission lines and several other heavy electrical equipment. Industrial noise is more intense in the frequency range of 1 MHz to 600 MHz.

Internal noise :- It is that type of noise which is generated internally or within the communication system or receiver. Internal noise may be treated quantitatively and can also be reduced or minimized by proper system design.

It is randomly distributed over the entire frequency spectrum, the noise present in a given bandwidth B is the same at any frequency in the frequency spectrum.

Shot Noise :- It arises in active devices due to random behaviour of charge carriers. In semiconductor devices shot noise is generated due to the random diffusion of minority carriers or simply random generation and recombination of electron-hole pairs.

Shot-noise is Gaussian distributed with a zero mean value.

Partition Noise :- It is generated in a circuit when a current has to divide between two or more paths. This means that the partition noise results from the random fluctuations in the division.

Flicker noise, or Low-Frequency Noise or (1/f) noise :- This kind of noise appears at low frequencies. The power spectral density of this noise increases as the frequency decreases.

In semiconductor devices, flicker noise is generated from the fluctuations in the carrier density and creates more problems in semiconductor amplifying device at low frequencies.

Transit-Time Noise or High Frequency Noise

It is observed in semiconductor devices, when the transit-time of charge-carriers crossing a junction is comparable with the time-period of the signal, some charge-carriers diffuse back to the source or emitter.

This process gives rises to an input admittance in which the conductance component increases with frequency.

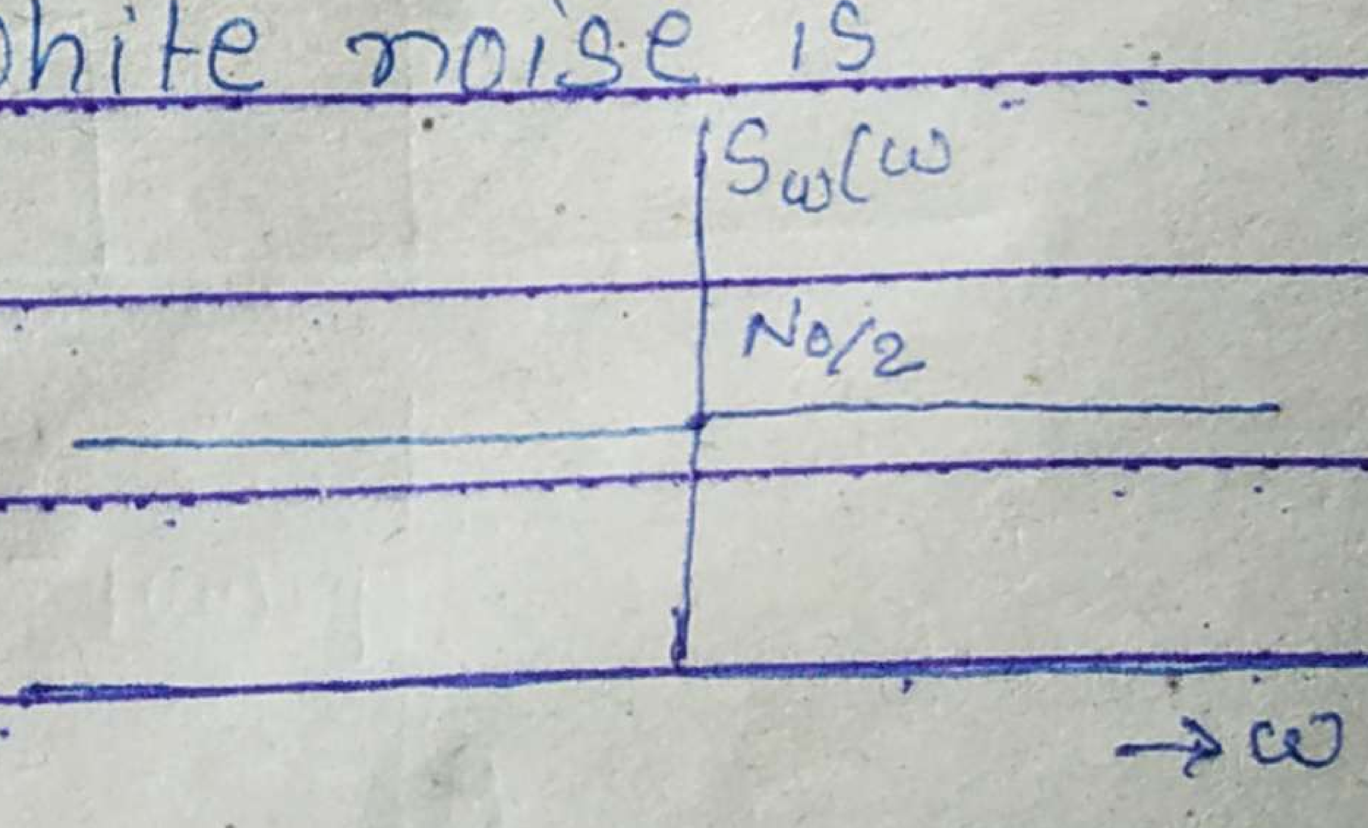
Thermal noise :- The thermal noise or white noise or Johnson noise is the random noise which is generated in a resistor or the resistive component of a complex impedance due to rapid and random motion of the molecules, atoms and electrons.

White Noise

Noise in an idalized form is known as white noise. As white light consists of all Colour frequencies, similarly white noise contains all frequencies in equal amount. The power density spectrum of white noise is independent of frequency. This means that white noise consists of all the frequency component in equal amount.

The power spectrum density of white noise is expressed as

$$S_w(\omega) = \frac{N_0}{2}$$

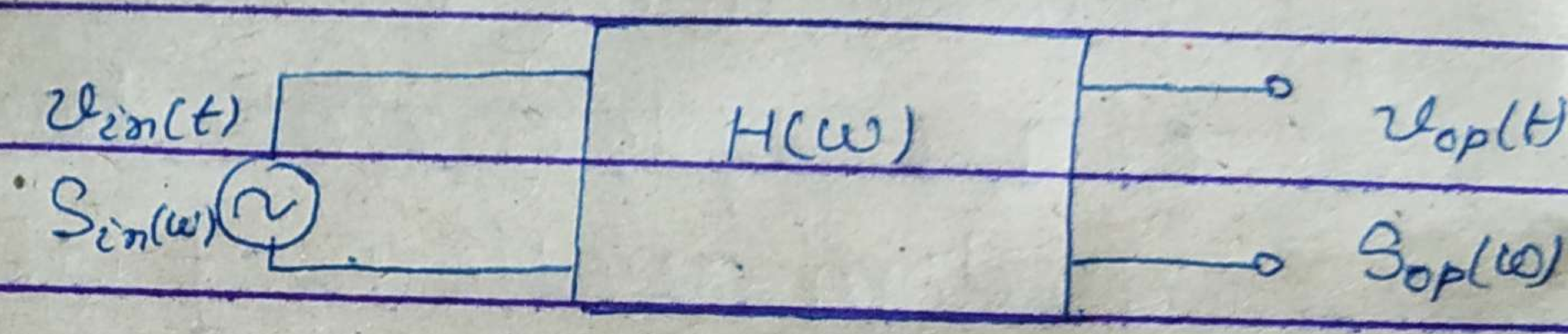


The autocorrelation function for the white noise is expressed as

$$R_w(\tau) = \frac{N_0}{2} \delta(\tau)$$

Equivalent Noise Bandwidth

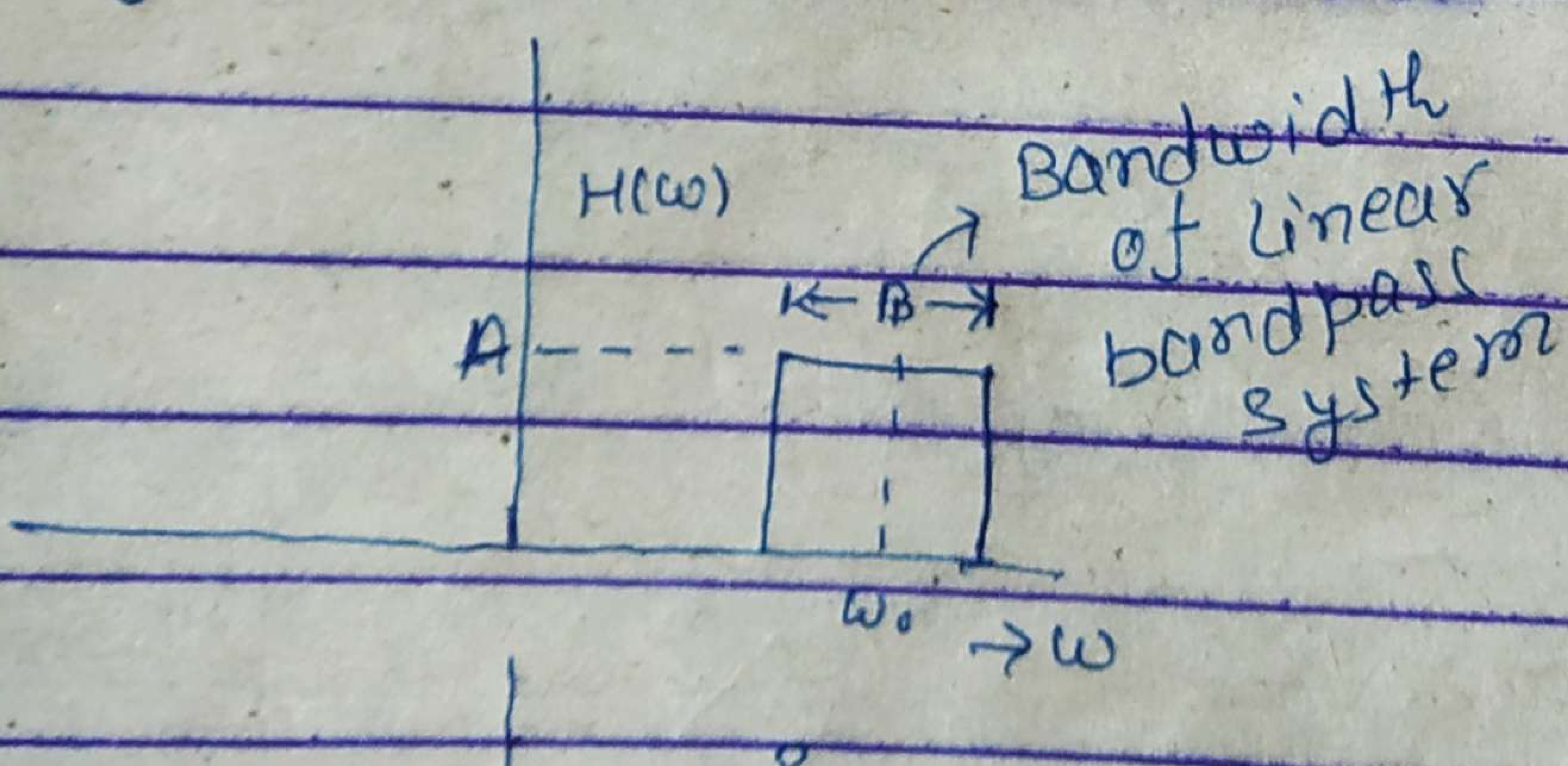
Let us consider a linear bandpass system.

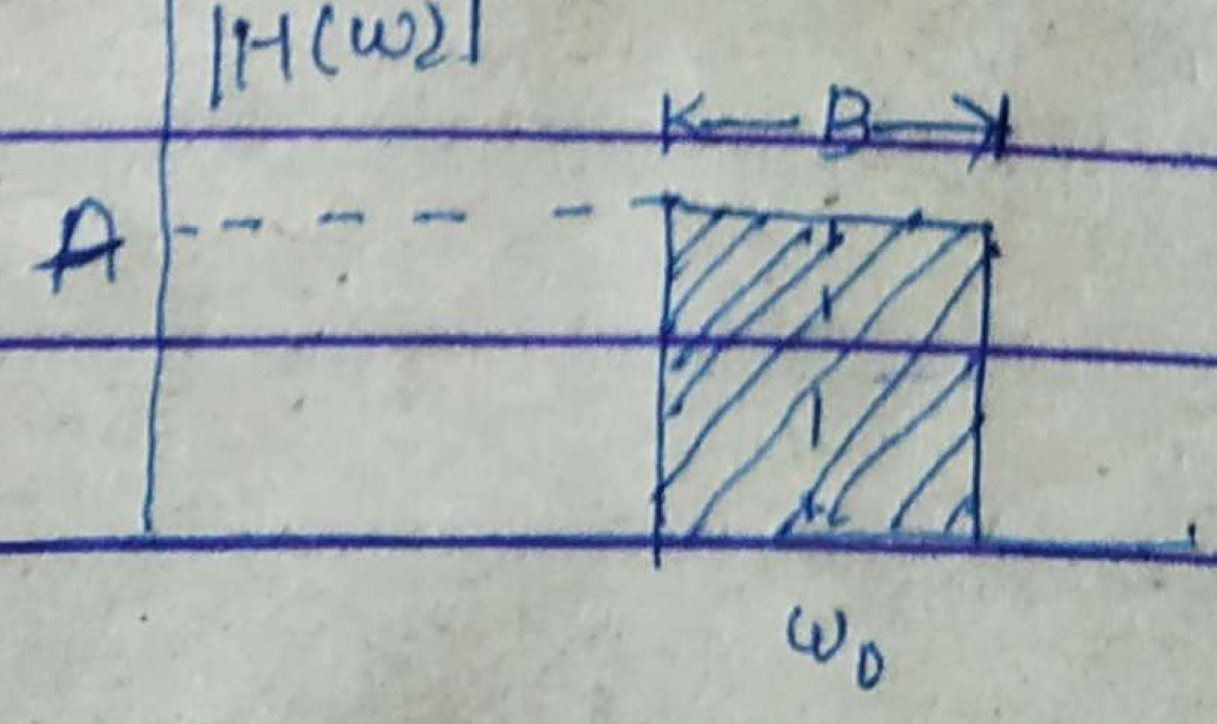


The system is excited by an input noise voltage $v_{in}(t)$ which in frequency domain is given as $S_{in}(\omega)$.

The noise output voltage is given by $v_{op}(t)$, which in frequency domain is given as $S_{op}(\omega)$

$H(\omega)$ be transfer function of linear bandpass system





Power spectrum density of noise voltage at the input and power spectrum density at the output are related as

$$S_{op}(\omega) = |H(\omega)|^2 \, S_{in}(\omega)$$

Output noise power can be calculated as

$$v_{op}^2(t) = P_o = \frac{1}{2\pi}\int_{-\infty}^{\infty} S_{op}(\omega)\, d\omega$$

$$v_{op}^2(t) = P_o = \frac{1}{\pi}\int_{0}^{\infty} S_{in}(\omega)|H(\omega)|^2\, d\omega$$

For the practical purpose, the input noise power spectrum density $S_{in}(\omega)$ is taken as constant

Let $S_{in}(\omega) = C$

$$\therefore \quad P_o = \frac{C}{\pi}\int_{0}^{\infty} |H(\omega)|^2\, d\omega$$

$$\therefore \quad P_o = \frac{C}{\pi} \times \text{area under the curve } |H(\omega)|^2$$

From Fig we get

$$P_o = \frac{C}{\pi} \times A \times B$$

$$\therefore \quad \overline{v_{on}^2} = P_o = \frac{ABC}{\pi}$$

Equivalent noise bandwidth may be defined as the bandwidth of an ideal bandpass system which produces the same noise power as the actual System does.

Signal to noise Ratio

The ratio of signal power to the associated noise power is defined as signal to noise ratio.

OR

The ratio of signal power to the noise power at the same point in the system.

It is denoted by S/N

If a signal voltage $v_s(t)$ is associated with a noise voltage source $v_n(t)$, then the ratio of signal power to the noise power will be

$$S/N = \frac{\overline{v_s^2}}{\overline{v_n^2}}$$

$\overline{v_s^2}$ = mean square value of signal voltage

v_n^2 = mean square value of noise voltage

$$\frac{S}{N} = \frac{S_s(\omega)}{S_N(\omega)}$$

$S_s(\omega)$ = Power spectrum density of signal

$S_n(\omega)$ = Power spectrum density of noise

Noise Figure (Noise Factor)

It is defined as the ratio of the signal-to noise power ratio supplied to the input terminals of a receiver or amplifier to the signal-to-noise ratio supplied to the output

Mathematically

$$\text{Noise figure } (F) = \frac{\text{Input SNR}}{\text{Output SNR}}$$