Noise

* Noise is a unwanted signal random in nature. Actually noise is a disturbance. Noise deu to presence of noise the reception and transmission of communication signal is disturbed. There are a number of types noise several types noise given bellow -

** **Thermal agitation Noise:-** Passive resistance is cause of thermal re noise. If passive resistance is present in the circuit then thermal noise is generated. Thermal noise is also called Johnson noise or white noise. White noise or thermal noise is characterised by uniform p.d.f.

Thermal noise power is directly proportional to bandwidth and temperature.

* $$P_n \propto T \delta f$$

$$\boxed{P_n = kT\delta f}$$

where P_n = Thermal noise power
k = Boltzman constant
$= 1.38 \times 10^{-23}$ J/k
T = absolute temperature in °k
δf = Bandwidth.

for Thermal noise voltage -

* $$P_n = \frac{V^2}{R_L} = \frac{(V_n/2)^2}{R_L} = \frac{V_n^2}{4R_L}$$

$$\therefore V_n^2 = 4R_L P_n$$

$$V_n = \sqrt{4R_L kT\delta f}$$

* $$\boxed{V_n = \sqrt{4R_L kT\delta f}}$$

where R_L ...

Problem:- An amplifier is operating over the frequency range 18 MHz to 20 MHz has 10 kΩ register. If ambient temperature is 27°C then find R.M.S noise voltage.

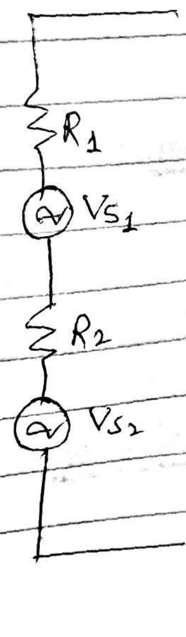
Solution :- Given.

$$\Delta f = \delta f = 20 MHz - 18 MHz$$
$$= 2 MHz$$
$$R_L = 10 k\Omega = 10 \times 10^3 \Omega$$
$$t = 27^\circ C \Rightarrow T = 27 + 273$$
$$= 300^\circ k$$
$$k = 1.38 \times 10^{-23} \text{ Juel} / K$$

Hence noise voltage.

$$V_n = \sqrt{4 R_L k T \delta f}$$
$$= \sqrt{4 \times 10 \times 10^3 \times 1.38 \times 10^{-23} \times 300 \times 2 \times 10^6}$$
$$= \sqrt{12 \times 1.38 \times 2 \times 10^{-13} \times 10^2}$$
$$= \sqrt{24 \times 1.38 \times 10^{-11}}$$
$$V_n = \underline{18.2 \times 10^{-6} \text{ volt}}$$

Condition :- I If resistor sources are connected in seriese then



$$V_{n_1}^2 = 4 R_{L_1} k T \delta f$$
$$V_{n_2}^2 = 4 R_{L_2} k T \delta f$$
$$\therefore V_n^2 = V_{n_1}^2 + V_{n_2}^2$$
$$= 4 k T \delta f (R_{L_1} + R_{L_2})$$
$$\therefore V_n = \sqrt{4 k T \delta f (R_1 + R_2)}$$

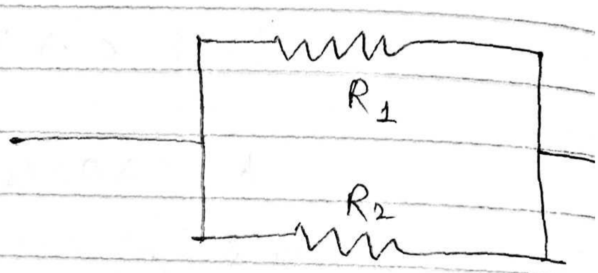
$$\therefore \quad V_n = \sqrt{4 R_{2eq} k T \delta f}$$

where

$$R_{2eq} = R_1 + R_2 + R_3 + \cdots$$

Condition II:- If resistor sources are connected in parallel combination then-

$$R_{1eq} = \frac{R_1 R_2}{R_1 + R_2}$$



Hence thermal noise voltage-

$$V_n = \sqrt{4 R_{1eq} k T \delta f}$$

* **Problem:-** Write formula of thermal noise voltage, when more than one sources are used.

* **Solution:-** Thermal noise voltage when more resistor sources are used-

$$V_n = \sqrt{4 R_2 k T \delta f}$$

$$V_n = \sqrt{4 (R_1 + R_2 + \cdots\cdots) k T \delta f}$$

* **Problem:** Calculate noise voltage at the input of a television R.F. amplifier using a device that have a 200 Ω equivalent noise resistance and 300 Ω input resistance. The bandwidth of amplifier is 6 MHz and temperature 17°C.

Solution

$R_1 = 200\,\Omega$

$R_2 = 300\,\Omega$

Date :
Page :

$R_{eq} = R_1 + R_2$
$= 200\,\Omega + 300\,\Omega$
$= 5'00\,\Omega$

$\delta f = 6\,MHz$
$= 6 \times 10^6\,Hz$

$T = 17°C + 273°k$
$= 290°k$

Hence Noise voltage.

$$V_n = \sqrt{4 R_L k T \delta f}$$

$$= \sqrt{4 \times 5'00 \times 1.38 \times 10^{-23} \times 290 \times 6 \times 10^6}$$

$$= \sqrt{2000 \times 1.38 \times 290 \times 6 \times 10^{-17}}$$

$$= \sqrt{12 \times 290 \times 1.38 \times 10^{-14}}$$

$$= 6.93 \times 10^{-6}\ \text{volt}$$

* **Problem** Two transistors $22k\Omega$ and $47k\Omega$ are room temp. for a bandwidth $100kHz$ calculate thermal noise voltage for —

ⓐ » For each resistor
ⓑ » For Resistor in seriese
ⓒ » For Resistor in parallel.

Problem Solution ⓐ» for $R = 22k\Omega$ $T = 27°C + 296° = 300k$

$$V_n = \sqrt{4 R_L k T \delta f}$$

$$= \sqrt{4 \times 22 \times 10^3 \times 1.38 \times 10^{-23} \times 28\ 300k \times 100 \times 10^3}$$

$$= \sqrt{88 \times 1.38 \times 3 \times 10^{-13}}$$

$$V_n = 10.21 \times 10^{-6} \text{ volt}$$

(c) when resistors are connected in parallel then-

$$R_{eq} = \frac{R_1 R_2}{(R_1+R_2)} = \frac{22 \times 47}{69}$$

$$= 14.98 k\Omega$$

Hence noise voltage —

$$V_n = \sqrt{4 R_L' k T \delta f}$$

$$= \sqrt{4 \times 14.98 \times 10^3 \times 1.38 \times 10^{-23} \times 300 \times 10^5}$$

$$= \sqrt{4 \times 3 \times 14.98 \times 1.38 \times 10^{-13}}$$

$$= 4.98 \times 10^{-6} \text{ volt}$$

**Shot Noise:- Shot Noise is generated due to shot effect. It is caused by random variation in the arival of electrons or holes at the output electrodes of amplifying device. The shot Noise formula for a device can be given by as bellow—

$$i_n = \sqrt{2 e i_p \delta f}$$

where

i_n = R.m.s shot Noise current

ech

e = charge on electron $= 1.6 \times 10^{-19}$ C

δf = Bandwidth

3

** **Noise Figure or Noise Factor or Noise Ratio** :- The noise figure, or noise factor is defined as bellow -

$$F = \frac{\text{signal to Noise ratio at Input}}{\text{signal to noise ratio at output}}$$

$$\boxed{F = 1 + \frac{R_{eq}'}{R_a}} = \frac{(S/N) \text{ at Input}}{(S/N) \text{ at output}}$$

where F = Noise figure
R_{eq}' = Noise equivalent Resistance
R_a = antenna Resistance

Always remember that this equation is aplicable only for mismatched conditions.

** **Noise temperature** :- Noise equivalent temperature is given as bellow -

$$\boxed{T_{eq} = T_0 (F-1)}$$

where
T_{eq} = Noise equivalent temperature
T_0 = Absolute temperature
$= 290°K$
F = Noise figure.

***Problem**:- A Reciever is connected to an antenna whose resistance is 50 Ω have a noise equivalent resistance of 30 Ω. Calculate Noise figure in dB and equivalent noise temperature.

Solution:-

Antenna Resistance = $R_a = 50\,\Omega$
Noise equivalent Resistance
$R_{eq}' = 30\,\Omega$