
بسم الله الرحمن الرحيم

Ministry of Higher Education and Scientific Research
Foundation of Technical Education
Technical College / Al-Najaf

Training package in

Noise

For students of second class

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1/ Over view

1 / A –Target population :-

For students of second class in Communications Techniques Engineering Department

1 / B –Rationale :-

After studying this package, you should be familiar the types and sources of noise. The methods of calculating the noise produced by various sources will be learned

1 / C –Central Idea :-

- **Define noise**
- **Random noise**
- **Thermal Noise**
- **Noise Figure**

1 / D –Objectives:

- **Define the word noise as it applies to this material**
- **Name at least six different types of noise.**
- **Demonstrate an understanding of signal-to-noise (S/N)**
- **Calculate noise figure**

2/ Pre test :-

Multiple Choice Questions With Answer

1. The noise in a temperature limited diode is

(a) Filcher noise (b) Thermal noise (c) Shot noise

١

2. The ideal value of noise figure is

(a) 1 dB (b) 0 dB (c) ∞ dB

٢

3. The RMS value of thermal noise power is proportional to ٣

(a) square root of bandwidth

(b) bandwidth

(c) reciprocal of bandwidth

(d) square of bandwidth

٤

5. In communication system noise is most likely to affect the signal

(a) at the transistor

(b) in the channel

(c) in the information source

(d) at the destination

3/ Performance Objectives :-

Noise

Noise: Undesired electrical signal which are introduced with a message signal during the transmission or processing of the latter are called noise. Noise is thus an unwanted signal that corrupts a desired message signal.

Random noise:

Random noise varies randomly with time. Identification of message signal at the receiver depends upon the amount of noise accompanied by the message during the process of communication. The presence of noise complicates the system of communication. The amount of noise power present in the received signal decides the minimum power level of the desired message signal at the transmitter.

The general classification of random noise There are
various sources of random noise they are broadly classified as

-External noise: sources are external i.e., outside the circuit

-Internal noise: noise is created by the active and passive components present within the circuit itself.

Thermal Noise

Thermal noise is produced as a result of the thermally excited random motion of free electrons in a conducting medium, such as a resistor. The path of each electron in motion is randomly oriented due to collisions. The net effect of the motion of all electrons is an electric current in the resistor which is random with a mean vale of zero.

From thermodynamic and quantum mechanical consideration, the power spectral density of thermal noise is given by

$$S_n = \frac{h|\mu|}{\circledR\,[\exp(h|\mu|/2\circledR kT) - 1]}$$

$S_n(\mu) = 2kT$ watts per Hz for $|\mu| << 2\circledR kT/h,$

T= temperature of the conducting medium in Kelvin,

K= Boltzmann’s constant= $1.38 \times 10^{-23}\ Joule/K,$

h= Plank’s constant= $6.625 \times 10^{-34}\ Joule - Sec.$

For frequencies above $kT / h,$ thermal noise is no longer white. However, these frequencies are so high for electrical signals that we can safely assume that thermal noise is white for our purposes here

(for example, KT/h= 6000 GHz for T=290 K).

the mean-square (open-circuit) voltage generated by a resistor R in a bandwidth B is

$$\overline{3^{2}(t)} = \frac{1}{2®}\int_{-2®B}^{2®B} 2KTR\,dμ, \qquad \overline{3^{2}(t)} = 4KTRB \quad volts^{2}.$$

the mean-square (short-circuit) current generated

$$\overline{i^{2}(t)} = \frac{1}{2®}\int_{-2®B}^{2®B} 2KTG\,dμ, \qquad \overline{i^{2}(t)} = 4KTGB \quad amperes^{2}.$$

Example:

Calculate the rms noise voltage at the input of a video amplifier using a device having 300 equivalent noise resistance and 400 Input resistor. It is given that the bandwidth of the amplifier is 7 MHz and the ambient temperature is 27 ºC

Solution: Given that

T=273 + 27= 300 ºK
Rs= R1 + R2
=300 + 400
Rs= 700
Bandwidth B=7 MHz

$$V_{nr} = \sqrt{4kTBR_s}$$

$$= \sqrt{4 \times 1.38 \times 10^{-23} \times 300 \times 7 \times 10^{6}}$$

$$V_{nr} = 9 \text{«} V$$

Example:

Find the noise figure of an amplifier for which noise equivalent resistance Req = 2518 and Rt = 600 . It is driven by a generator whose output impedance is 50 . It is given that this constitutes a enough mismatch.

Solution: Given that Req = 2518, Rt = 600, Ra = 50

$$F = 1 + \frac{R'_{eq}}{R_a}$$

$$F = 1 + \frac{1918}{50}$$

$$F = 1 + 38.4 = 39.4$$

$$F_{1n} dB = 10 \log_{10} (39.4)$$

$$= 15.84\, dB$$

Noise Figure

Let the input and output signal voltages (or currents) in a given system be Si(t), So(t), respectively, and let the input and output noise voltages (or currents) be ni(t), no(t). The input-to-noise ratio, (S/N)i, is

$$(\mathrm{S/N})_{\mathrm{i}} = \overline{s_i^{\,2}(t)} \Big/ \overline{n_i^{\,2}(t)},$$

the output signal-to-noise ratio is

$$(\mathrm{S/N})_o = \overline{s_o^{\,2}(t)} \Big/ \overline{n_o^{\,2}(t)}$$

The noise figure, F, to be the ratio of the input signal-to-noise ratio divided by the output signal-to-noise ratio:

$$F = \frac{(S/N)_i}{(S/N)_o} \qquad F = 1 + \frac{T_e}{T_o}$$

The noise figure in decibels:

$$F_{dB} = 10 \log_{10}(F)$$

Note: **The standard value for To is 290 K.**

The noise figure, F, to be the ratio of the input signal-to-noise ratio divided by the output signal-to-noise ratio:

$$F = \frac{(\mathrm{S/N})_{\mathrm{i}}}{(\mathrm{S/N})_{\mathrm{o}}}$$

or

$$F = 1 + \frac{T_e}{T_o}$$

The noise figure in decibels:

$$F_{dB} = 10 \log_{10}(F)$$

<u>Note:</u> The standard value for To is 290 K.

Example:

first stage has a noise figure of 2 dB and a power gain of 12 dB. The second stage has a noise figure of 6 dB and a power gain of 10 dB. Find the overall Noise Figure in dB.

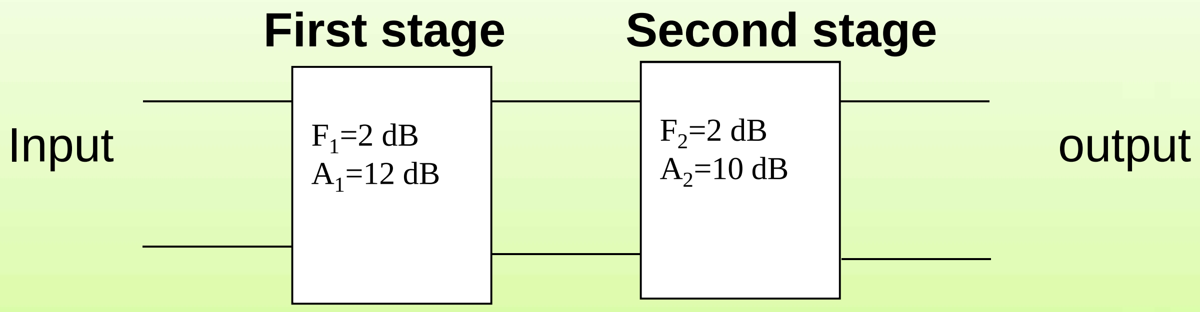

Fig. Overall noise figure F determination of a two-stage amplifier

Solution:

$$F_{dB} = 10\log_{10}(F_{ratio})$$

$$2 = 10\log_{10}(F_{1ratio})$$

$$(F_{1,ratio}) = Anti\ \log_{10}\left(\frac{2}{10}\right)$$

$$(F_{1,ratio}) = Anti\ \log_{10}(0.2)$$

$$(F_{1,ratio}) = 1.59$$

In the same way

$$(F_{2,ratio}) = 4, (A_{1,ratio}) = 15.9$$

$$(A_{2,ratio}) = 10$$

$$F = 1.59 + \frac{4-1}{15.9}$$

$$F = 1.59 + \frac{3}{15.9} = 1.779$$

$$F_{dB} = 10\log_{10}(F_{ratio})$$

$$F_{dB} = 10\log_{10}(1.779)$$

$$F_{dB} = 2.5\,dB$$

Quiz /

Define the following terms

١ **Noise** is thus an unwanted signal that corrupts a desired message signal.

٢ **Shot noise** or schottly noise rises due to the fact that in a tube or a semiconductor device the current flow due to the movement of discrete electric charges carried by electrons or holes and this current flows not a perfect continuous flow.

5/ Post test :-

1. One of the following type of noise of great importance at high frequencies.

(a) Shot noise (b) Random noise

(c) Impulse noise (d) transit-time noise

6. Thermal noise is also known as

(a) Johnson noise (b) modulation noise

(c) Flicher noise (d) shot noise

References

1. T. R. Ganesh Babu, and G. Srinivasan: " Communication Theory and systems", 2006.

2. Sanjay Sharma: "Communication Systems (Analog and Digital) "

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