EC8491-Communication Theory

UNIT-IV –NOISE CHARACTERIZATION

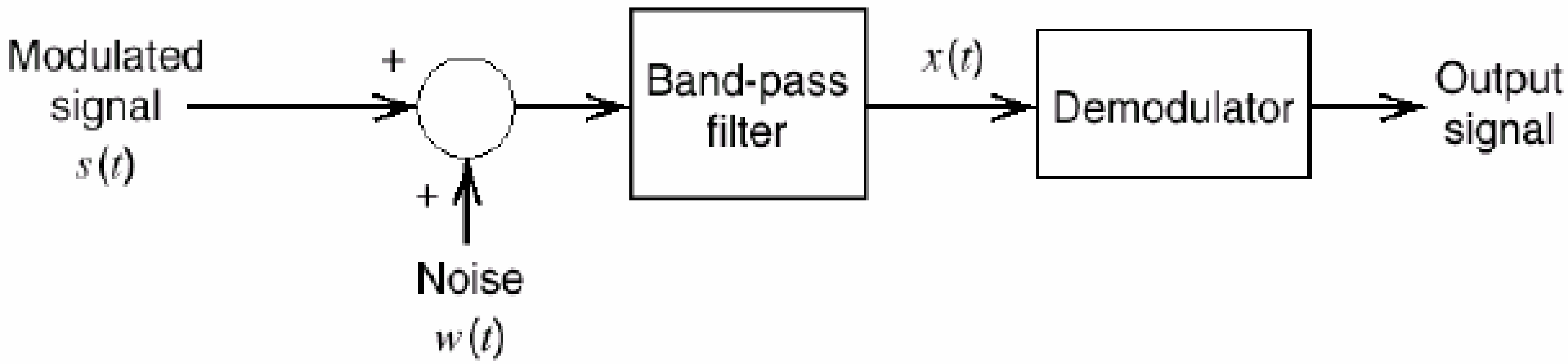
PRESENTED BY

S.SUDHAKAR B.E.,M.E.,MISTE.,

ASSISTANT PROFESSOR-ECE

NPRCET,DINDIGUL.

Noise in CW Modulation Systems



- To simplify the system analysis, we assume:
  - ideal band-pass filter (that is just wide enough to pass the modulated signal $s(t)$ without distortion),
  - ideal demodulator,
  - Gaussian distributed white Noise process.
- So the only source of imperfection is from the noise.

Noise in CW Modulation Systems

- *Input signal-to-noise ratio* $(SNR)_I$ is defined as:

$$(SNR)_I = \frac{\text{average power of the modulated signal } s(t)}{\text{average power of the filtered noise } n(t)}$$

- *Output signal-to-noise ratio* $(SNR)_O$ is defined as:

$$(SNR)_O = \frac{\text{average power of the demodulated message signal}}{\text{average power of the noise}}$$

- *Channel signal-to-noise ratio*

$$(SNR)_C = \frac{\text{average power of the modulated signal}}{\text{average power of noise in the message BW}}$$

Noise in CW Modulation Systems

- We normalize the receiver performance by dividing the output signal-to-noise ratio by the channel signal-to-noise ratio.

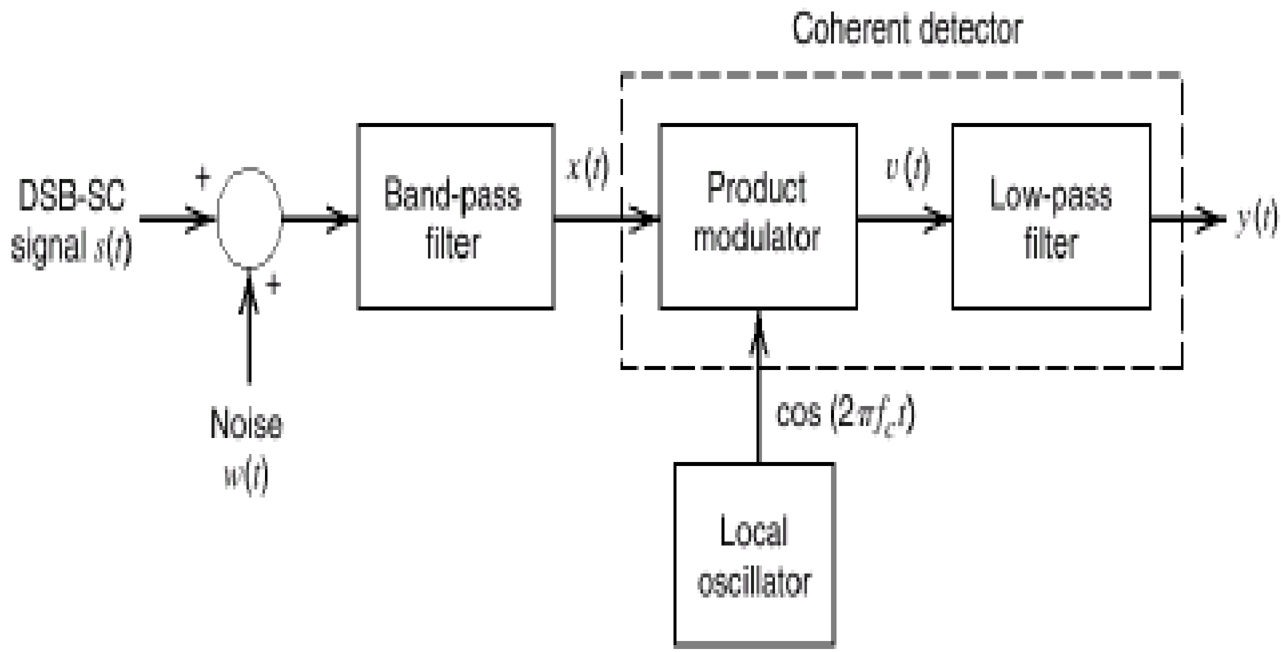
◊ The higher the value of the figure of merit, the better will the noise performance of the receiver .

◊ The figure of merit may equal one, be less than one, or be greater than one, depending on the type of modulation used.

$$\text{Figure of merit} = \frac{(SNR)_O}{(SNR)_C}$$

Noise in DSB-SC Receiver

- The model of a DSB-SC receiver using a coherent detector



Noise in DSB-SC Receiver

- Therefore, the average power of the DSB-SC modulated signal component $s(t)$ is given by: $\dfrac{C^2 A_c^2 P}{2}$
- The average power of the noise in the message BW is WN_0
- The channel signal-to-noise ratio of the DSB-SC modulation system is:

$$\left(\mathrm{SNR}\right)_{C,\mathrm{DSB}} = \frac{C^2 A_c^2 P}{2WN_0}$$

Introduction

Superheterodyne Receiver

- ***AM Receivers*** - receive broadcast of speech or music from AM transmitters which operate on long wave, medium wave or short wave bands.
- ***FM Receivers*** – receive broadcast programs from FM transmitters which operate in VHF or UHF bands.
- ***Communication Receivers*** - used for reception of telegraph and short wave telephone signals.
- ***Television Receivers*** - used to receive television broadcast in VHF or UHF bands.
- ***Radar Receivers*** – used to receive radio detection and ranging signals

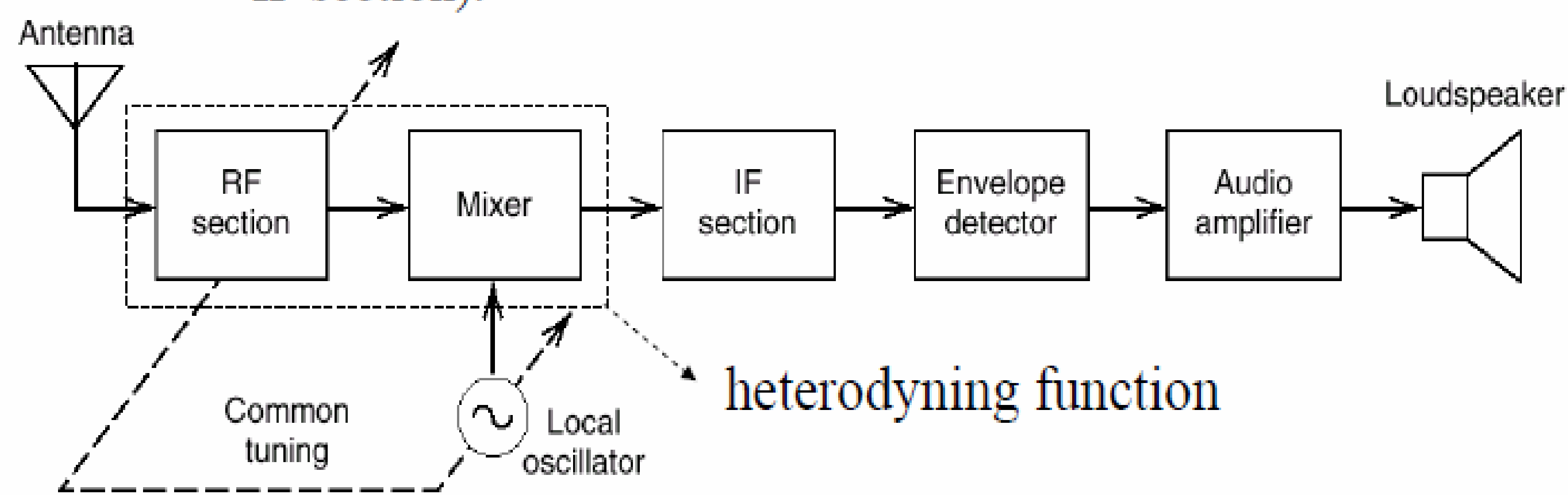
Superheterodyne Receiver

- A commercial radio communication system contains not only the “transmission” but also some other functions, ***such as:***
- ***Carrier-frequency tuning*** : to select the desired signals

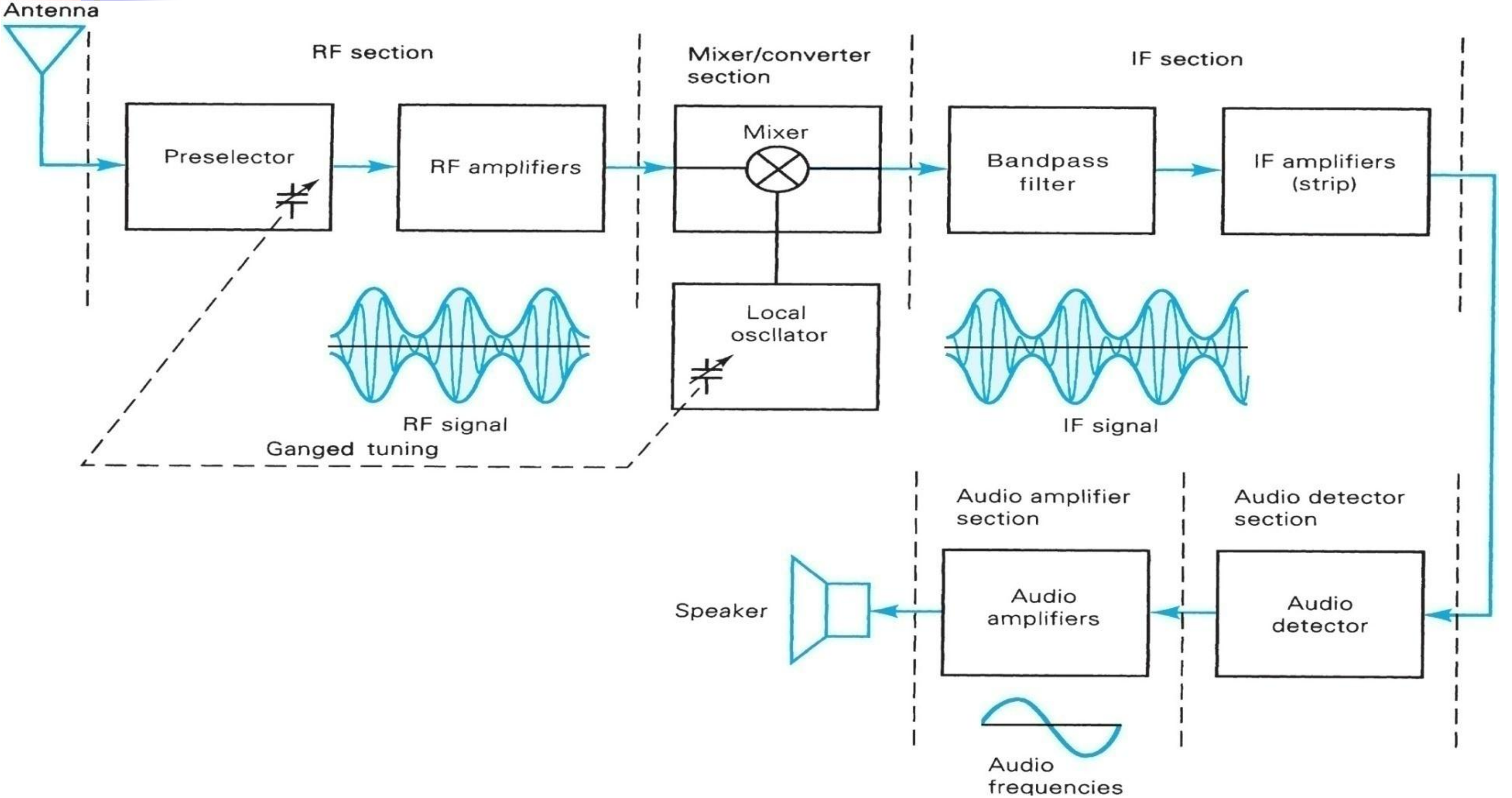
  (i.e., desired radio or TV station)
- ***Filtering:*** to separate the desired signal from other unwanted signals
- ***Amplifying: to*** compensate for the loss of signal power incurred in the course of transmission

Superheterodyne Receiver

- A *superheterodyne* receiver or *superhet* is designed to facilitate the fulfillment of these functions, especially the first two.
  - It overcomes the difficulty of having to build a *tunable highly selective and variable* filter (rather a fixed filter is applied on IF section).



Superheterodyne Receiver



Superheterodyne Receiver

- ***Heterodyne*** *– to mix two frequencies together in a nonlinear device or to transmit one frequency to another using nonlinear mixing.*

- Also known as ***frequency conversion*** , high frequency down converted to low frequency.(IF)

- A super heterodyne receiver converts all incoming radio frequency (RF) signals to a lower frequency known as an ***intermediate frequency (IF).***

Superheterodyne Receiver

Example	*AM Radio*	*FM Radio*
RF carrier range	0.535-1.605 MHz	88-108 MHz
Midband frequency of IF section	0.455 MHz	10.7 MHz
IF bandwidth	10 kHz	200 kHz

Table1:Frequency parameters of AM and FM radio receivers.

Superheterodyne Receiver

- When local oscillator frequency is tuned above the RF – ***high side injection***
- When local oscillator frequency is tuned below the RF – ***low side injection***
- ***Mathematically expressed :***

High side injection $f_{lo} = f_{RF} + f_{IF}$

Low side injection $f_{lo} = f_{RF} - f_{IF}$

Characteristics of Superheterodyne Receiver

- ***Sensitivity*** - ability to amplify the weak signals .
- ***Selectivity*** of radio receiver is its ability to differentiate desired signal from unwanted signals.
- ***Fidelity-*** the ability of the receiver to reproduce all the range of modulating frequencies.
- ***Image frequency:*** $f_{im} = f_{RF} + 2f_{IF}$
- ***Image Frequency rejection ratio***: $IFRR = \sqrt{(1 + Q^2\rho^2)}$

  Where $\rho = (f_{im}/f_{RF}) - (f_{RF}/f_{im})$

Noise

- Noise is ***unwanted*** electrical or electromagnetic energy that degrades the quality of signals and data.
- Noise occurs in digital and analog systems, and can affect files and communications of all types, including text, programs, images, audio signal etc…
- Random noise occurs in any practical information transmission system. Its value at any instant is unpredictable.

Received signal = Actual signal + Noise

- Random noise is an unwanted signal, producing errors or changes in amplitude of the actual signal and reducing the overall information transfer.

Noise

- The term noise is used to designate ***unwanted signals*** that tend to disturb the transmission and processing of signals in communication systems.
- The sources of noise may be external & internal to the system.
- ***External Noise***:

  1.Atmospheric Noise

  2. Man-made Noise

- ***Internal Noise***: 1. Shot noise

  2.Thermal noise

  3. Partition noise

External Noise

Natural Disturbances:(Atmospheric Noise)

- It is caused by lightening, electrical storms and atmospheric disturbances.
- This is random in nature ,and also called as atmospheric noise or static noise.
- Apart from this extra terrestrial noise is also created by erratic natural disturbances.

Man Made Noise:

- It is undesired pick-up from electrical appliances.
- This noise is under human control and can be eliminated by removing the source of noise.

Internal Noise(Fluctuation noise)

- It is created by the active and passive components present within the communication circuits.
- Fluctuation noise is created due to the spontaneous fluctuations present in the physical system.

- ***Examples:*** 1.Thermal motion of the free electron inside the resistor.

  2. Random emission of electron in vacuum tubes.

  3.Random diffusion of electrons and hole in a semiconductor.

Internal Noise

- ***Shot noise*** arises in electronic devices such as diodes and transistors because of discrete nature of current flow in these devices.

- ***Thermal noise*** is the electrical noise which is arising from the random motion of electron in a conductor.

- ***Partition noise*** occurs wherever current has to divide between two or more paths and partition noise results due to the random fluctuations in the division of current.

Thermal Noise

- ***Thermal noise*** is the electrical noise which is arising from the random motion of electron in a conductor.
- This type of noise is generated by all resistances (e.g. a resistor, semiconductor, the resistance of a resonant circuit, i.e. the real part of the impedance, cable etc).
- ***Noise power:***

Available Noise Power

$$P_{AVAIL} = k \cdot T \cdot \Delta f$$

Thermal Noise

The mean square noise voltage as

$$\overline{V}^2 = 4kTBR\ (volt^2)$$

Where k = Boltzmann's constant = 1.38×10^{-23} Joules per K

T = absolute temperature

B = bandwidth noise measured in (Hz)

R = resistance (ohms)

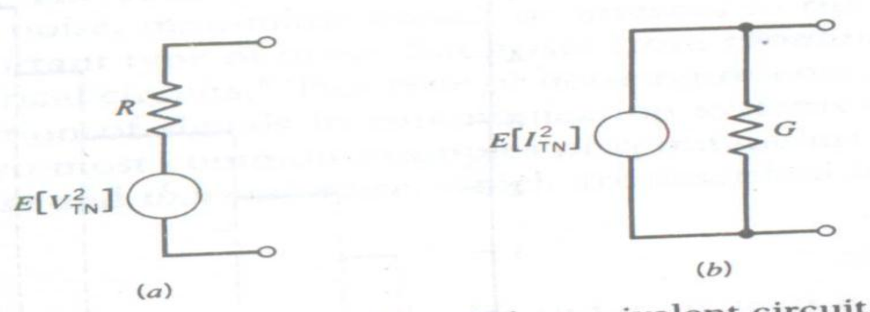


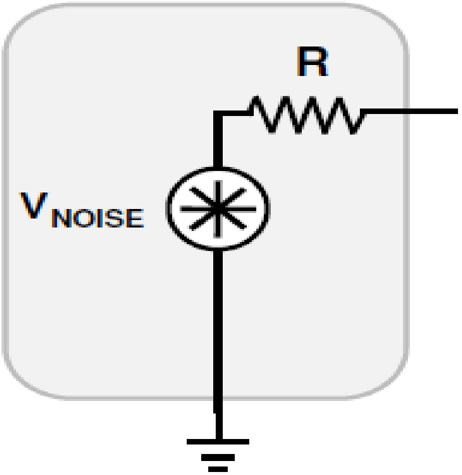
FIGURE 1.15 Models of a noisy resistor. (a) Thévenin equivalent circuit. (b) Norton equivalent circuit.

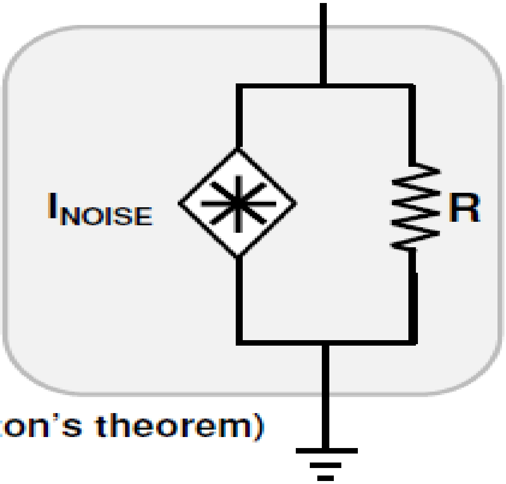
Thermal Noise

$$V_{NOISE} = \sqrt{4kTR\Delta f}$$

$$I_{NOISE} = \sqrt{\frac{4kT\Delta f}{R}}$$

Resistor Noise Models

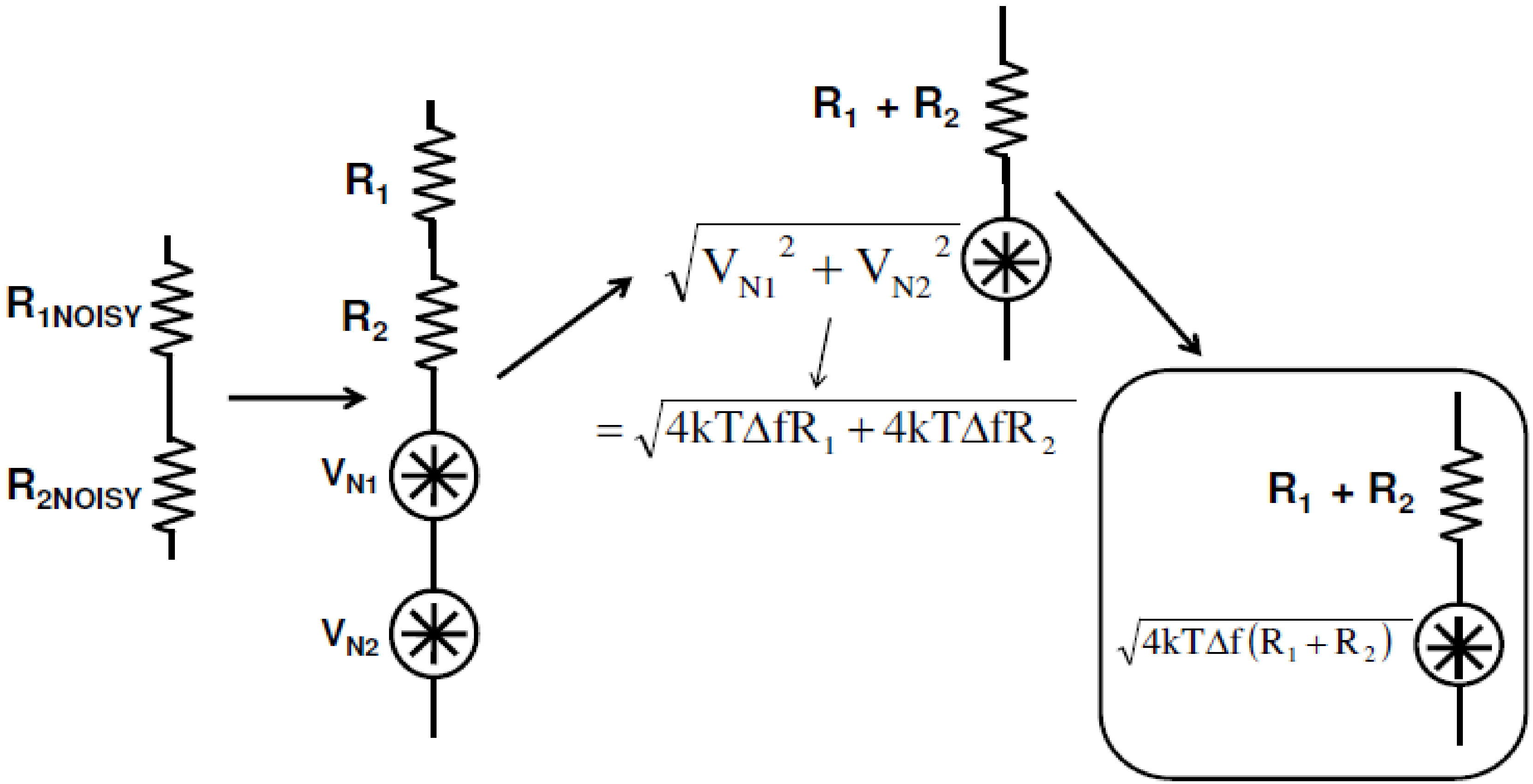




(From Norton's theorem)

Thermal Noise

What about R in series?



THANK YOU