# ANALOG & DIGITAL COMMUNICATION

Introduction [Lecture 1 ]

# Evaluation scheme

- Quiz 1 ------ 10 %
- Mid semester exam ------- 25 %
- Quiz 2 ------- 10%
- Project --------- 15 %
- End semester Exam ----- 40%

# Attendance

- The normal grade drop policy applies

# Signals and systems- Review

- What is a signal ?
- Distinction between analog and digital signal
- Time domain description
- Convolution
- Impulse response
- Frequency domain description of signal
- Transfer function of a system

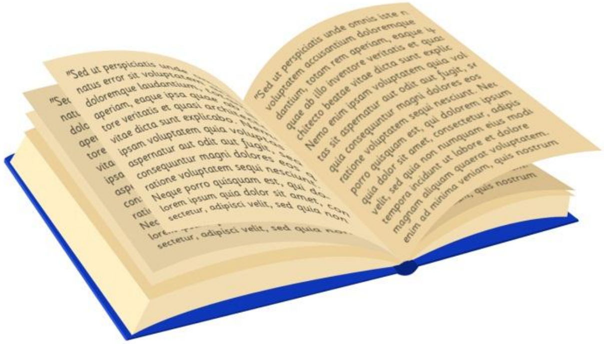
# What does a communication system do?

- Transmits information from a source to destination.
- What is the nature of information?

What is heard (Audio)

What is seen

Text , Image ,Video



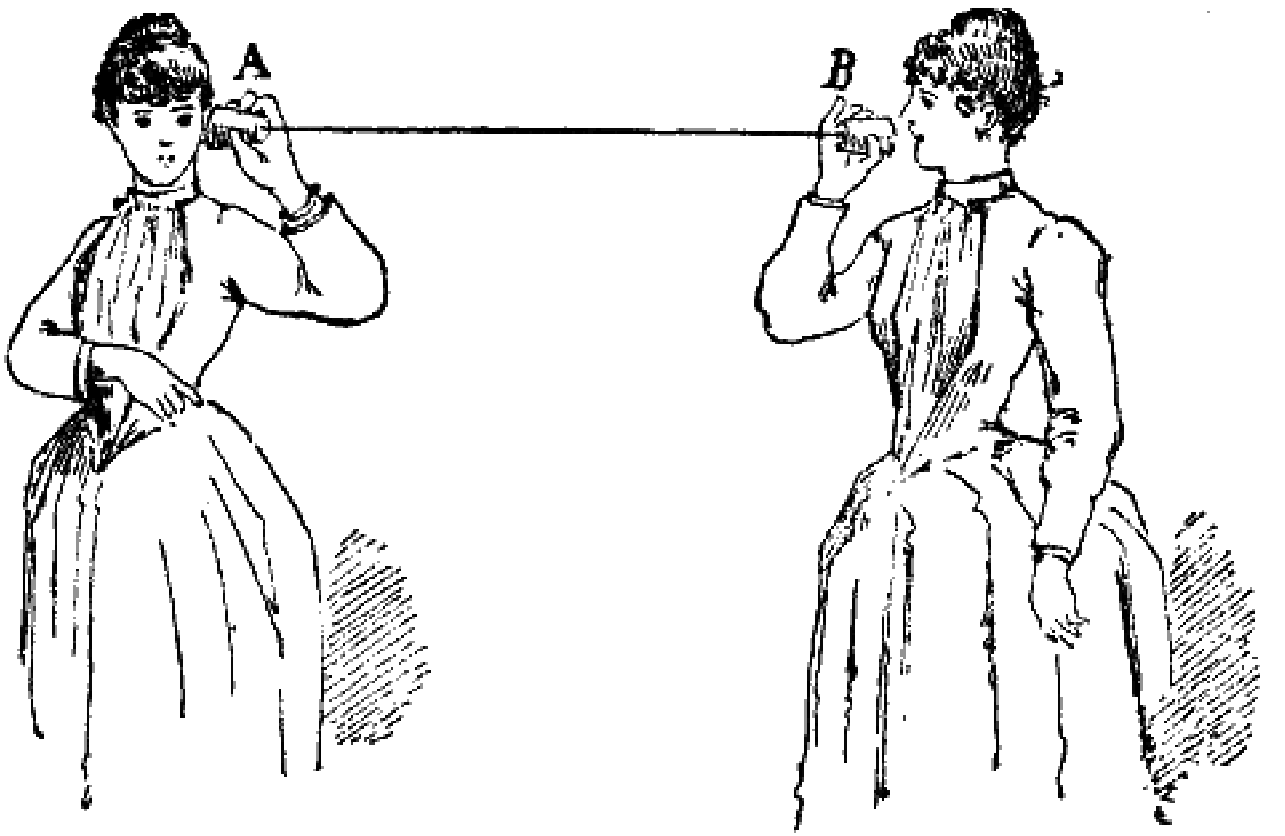
# Video

# Information transmitted as an electric signal

- Why?

  Transmission is easy

# Mechanical transmission



# Easy processing

- Amplification
- Addition
- Multiplication
- Differentiation
- Integration

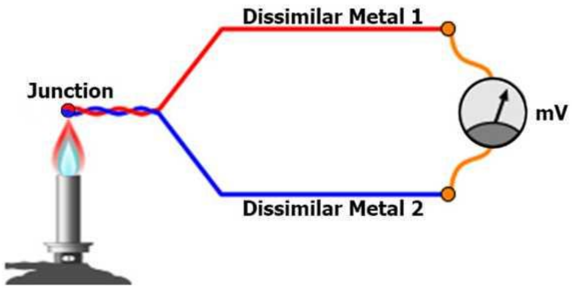
# Transducers

- These convert a given signal into an electrical signal
- Also convert an electrical signal into the desired form
- Sound to Electrical
- Electrical to Sound

# Other transducers

- Temperature to Electrical

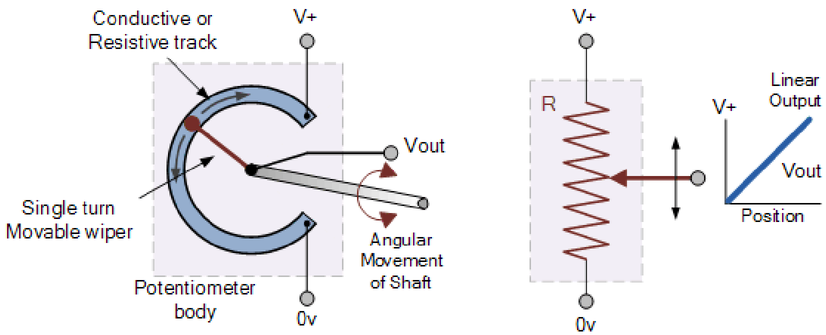
  Thermocouple




- Electrical to Temperature : Heater

# Some more transducers

Mechanical to Electrical : Potentiometer



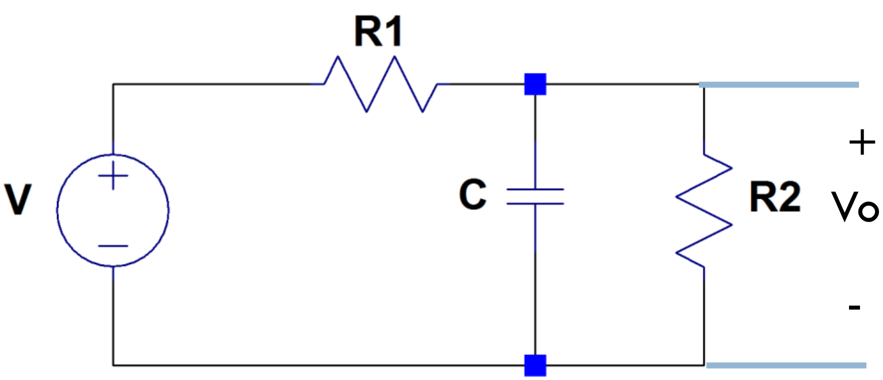

Electrical to Mechanical : Motor

# Two important aspects in communication systems

- Frequency response of the channel
- Noise

# Frequency response of the line

WIRED SYSTEM


$$At \;\; f = 0$$

$$Voltage\,Gain \;\; A = \frac{Vo}{V} = \frac{R_2}{R_1 + R_2}$$

$$For \;\; no \;\; distortion$$

$$f_c \geq f_{\max}$$

*Shorter the line , smaller is R1 and C and fc is larger*

$$Cut - off \;\;\; frequency$$

$$f_c = \frac{1}{2\pi R_p C} \;\; : R_p = \frac{R_1 R_2}{R_1 + R_2}$$

# Attenuation in dBs

*Attenuation is defined as the reciprocal of the gain*

$$\alpha = \frac{1}{A} = \frac{R_1 + R_2}{R_2}$$

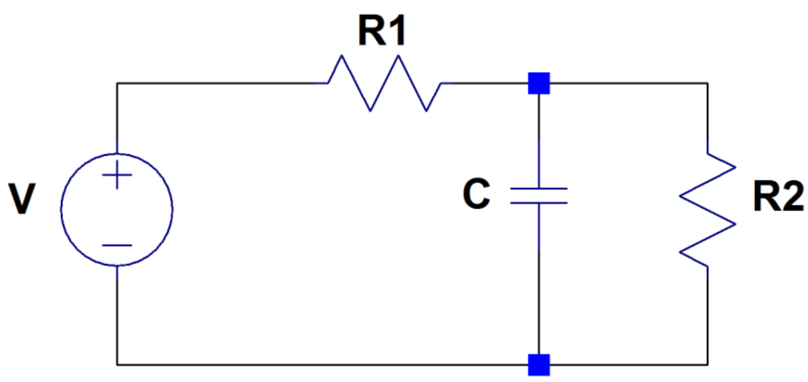
$$\alpha\,(dB) = 20\log\frac{R_1 + R_2}{R_2}$$

$$A = \frac{R_2}{R_1 + R_2} = 0.8$$

$$A = -1.9382\ dB$$

$$\alpha = 1.9382\ dB$$

# Problem 1




*Show that*

$$A = \frac{R_2}{(R_1 + R_2)\left(1 + \frac{j\,f}{f_p}\right)}$$

$$where \;\; f_p = \frac{1}{2\pi R_p C} \;\; and \;\; R_p = \frac{R_1 R_2}{R_1 + R_2}$$

Suppose the transmission line resistance is 168 ohms/km. Find the attenuation at zero frequency and also find the cut-off frequency if the transmission line is 10 km long and is terminated in 600 ohms resistance. C = 50nF

# Answers to problem 1

- Attenuation at zero frequency : 11.6 dBs
- Cut-off frequency : 7200 Hz

# Final slope of frequency response

$$A = \frac{R_2}{(R_1 + R_2)\left(1 + \frac{j\,f}{f_p}\right)}$$

$$A = \frac{A_0}{\left(1 + \frac{j\,f}{f_p}\right)} \quad Where\ A_0 = \frac{R_2}{R_1 + R_2}$$

$$When\ \ f << f_p\ \ : A \approx A_0$$

$$If\ \ f\ \ increases\ 10\ times$$

$$|A|_{dB}^{'} = 20\log(A_0 f_p) - 20\log 10 f$$

$$= \ 20\log(A_0 f_p) - 20\log f - 20$$

$$When\ \ f = f_p$$

$$|A| = \frac{A_0}{\sqrt{2}}$$

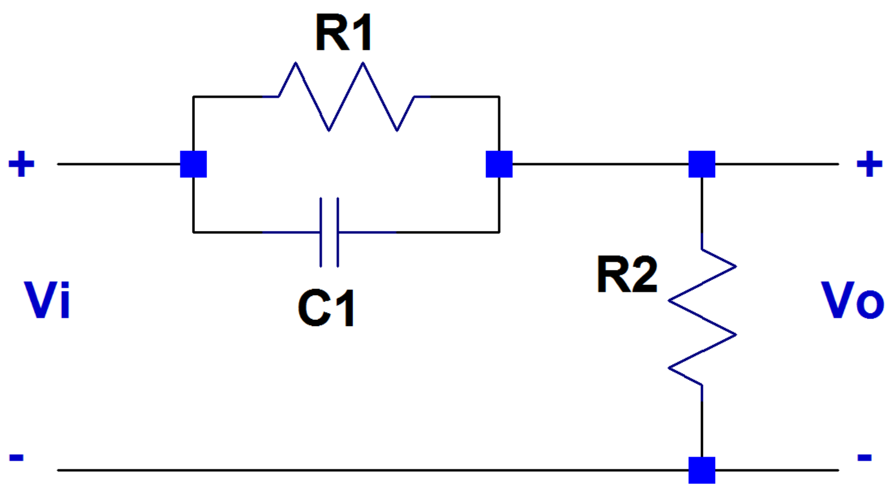
$$When\ f >> f_p$$

$$|A| = \frac{A_0 f_p}{f}$$

$$|A|_{dB} = 20\log\frac{A_0 f_p}{f} = 20\log(A_0 f_p) - 20\log f$$

So the slope is
– 20 dB/Decade

# Equalizer transfer function




*Show that*

$$A = \frac{R_2\left(1 + j\dfrac{f}{f_z}\right)}{(R_1 + R_2)\left(1 + j\dfrac{f}{f_p}\right)}$$

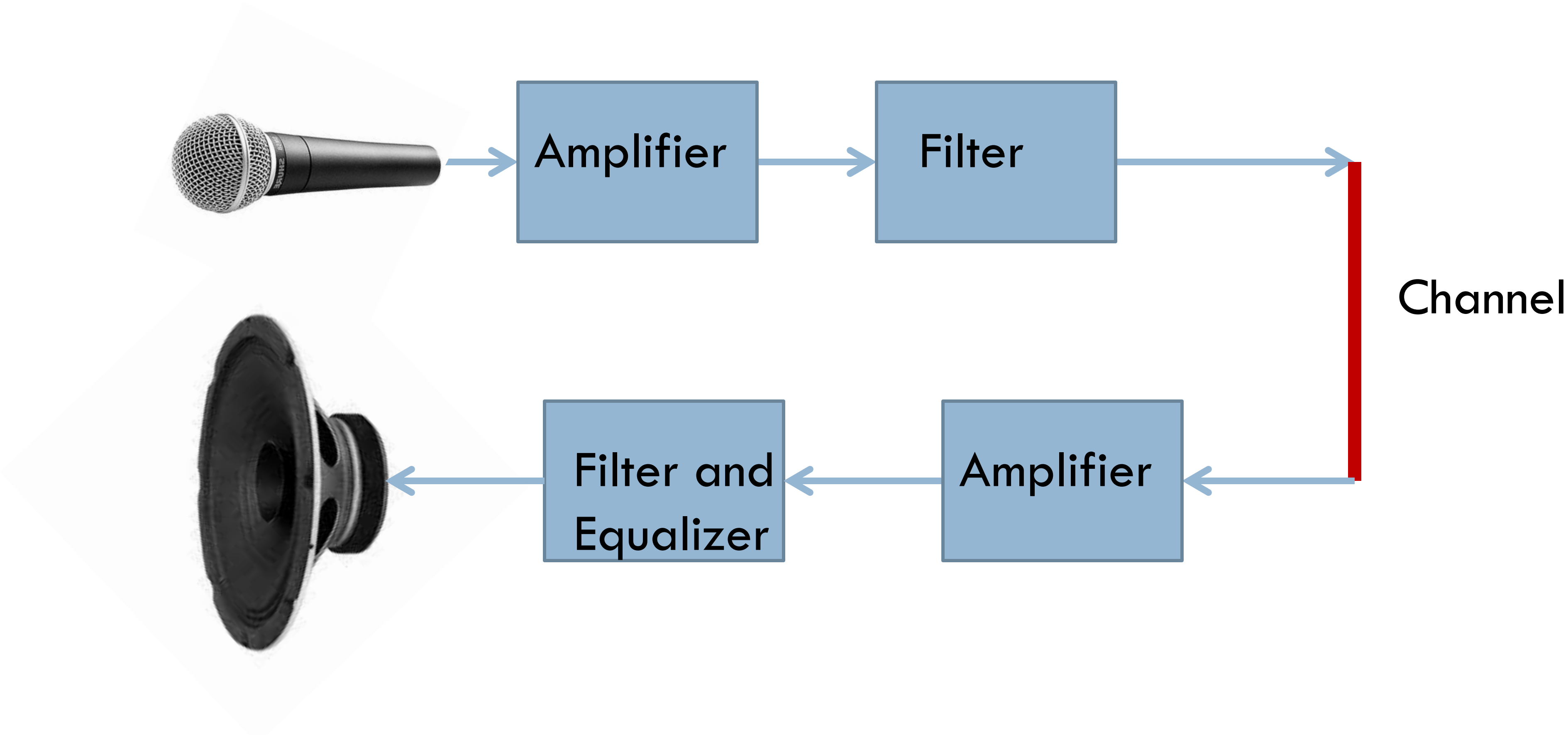
$$where \quad f_z = \frac{1}{2\pi C_1 R_1} \quad and \quad f_p = \frac{1}{2\pi R_p C_1}$$

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

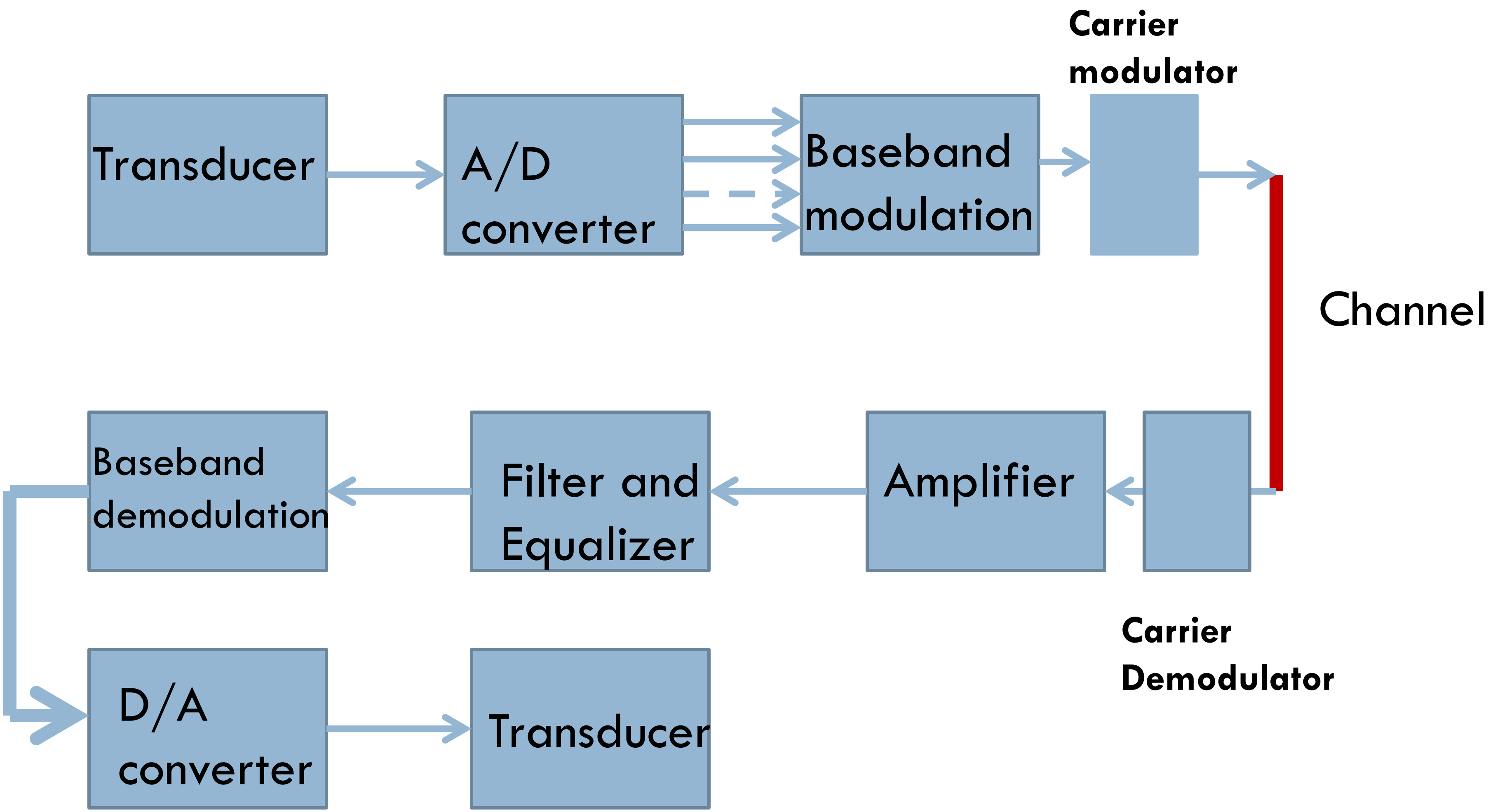
# Noise

- Noise in receiver
  - Thermal noise generated in resistors at receiver
  - Noise within active devices
- Remedies
  - Large transmitted power
  - Filtering
  - Coding

# Wired Analog systems



# Wired Digital systems



# Wireless systems

- When current changes in a wire(Antenna) it radiates an electromagnetic wave
- For efficient transmission the antenna length is of the order of $\lambda/2$ or $\lambda/4$
- Baseband signals are low frequency signals

  Antenna size required are impractical
- Need modulation

  This translates the frequency spectrum to high frequencies

# Attenuation in wireless systems

- In electromagnetic radiation field strength decreases as the square of the distance
- Amplification required at the receiver

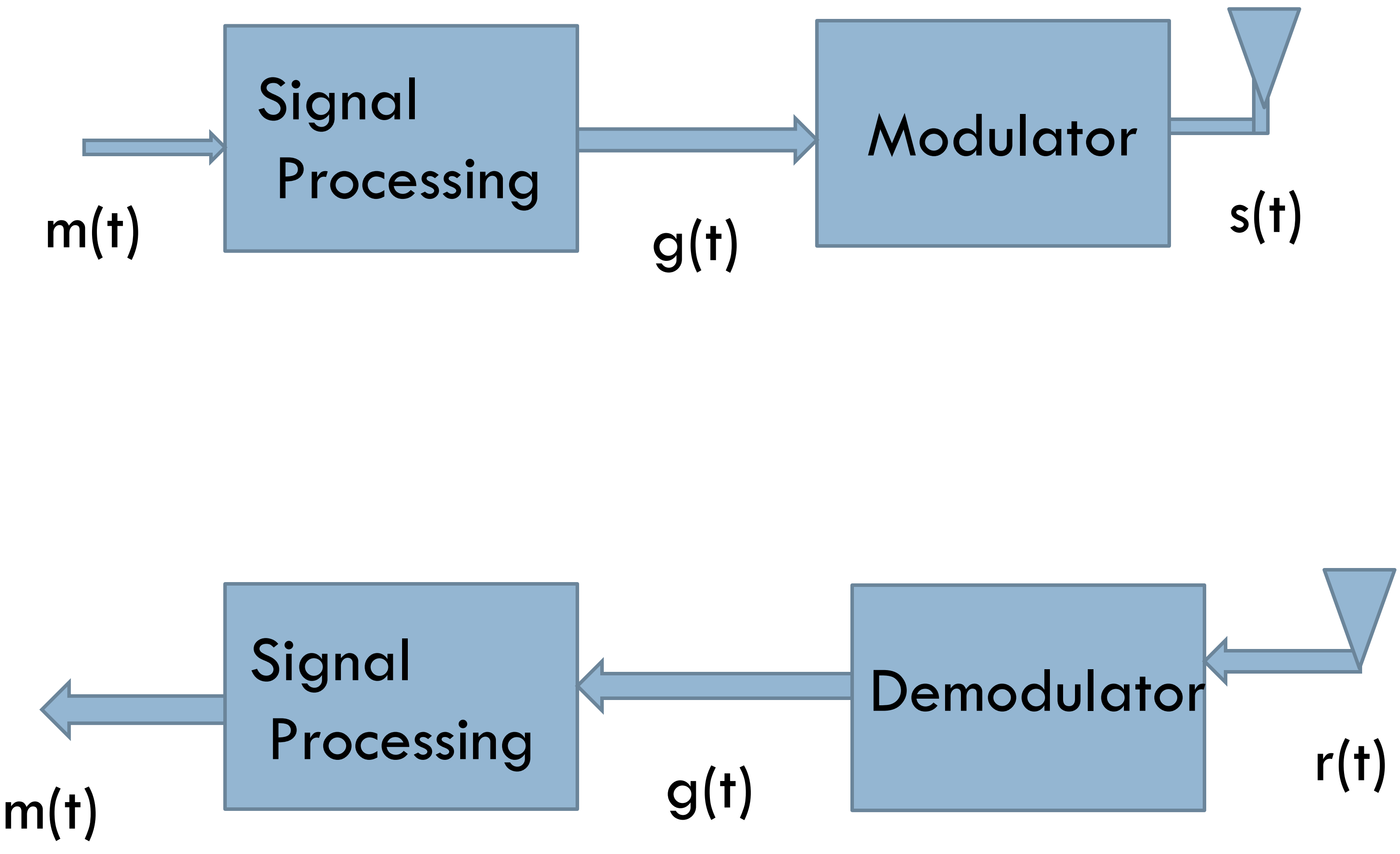
# Distortion in wireless systems

- Non-linearity in devices
  - Feedback
- Inadequate frequency response of wireless channels
  - Equalizers

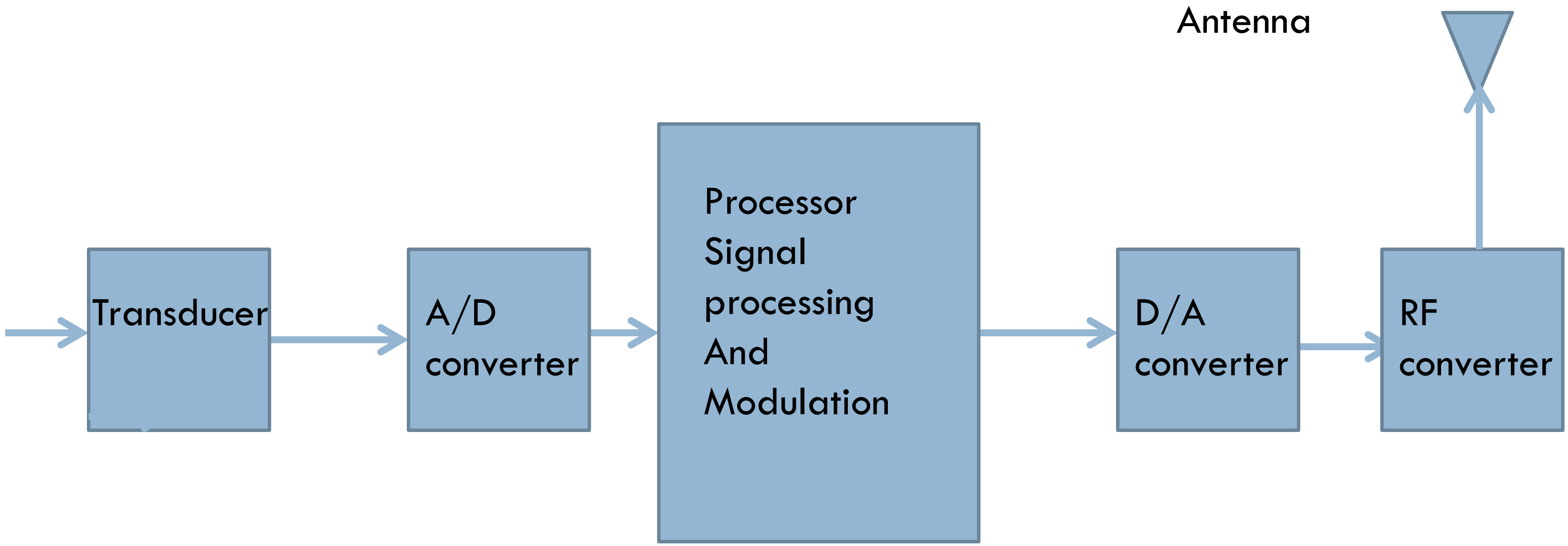
# Noise

- External noise :
  Automobile ignition system
  Radiation from outer space
- Noise in receiver
  Thermal noise generated in resistors at receiver
  Noise within active devices
- Remedies
  Large transmitted power
  Filtering
  Coding

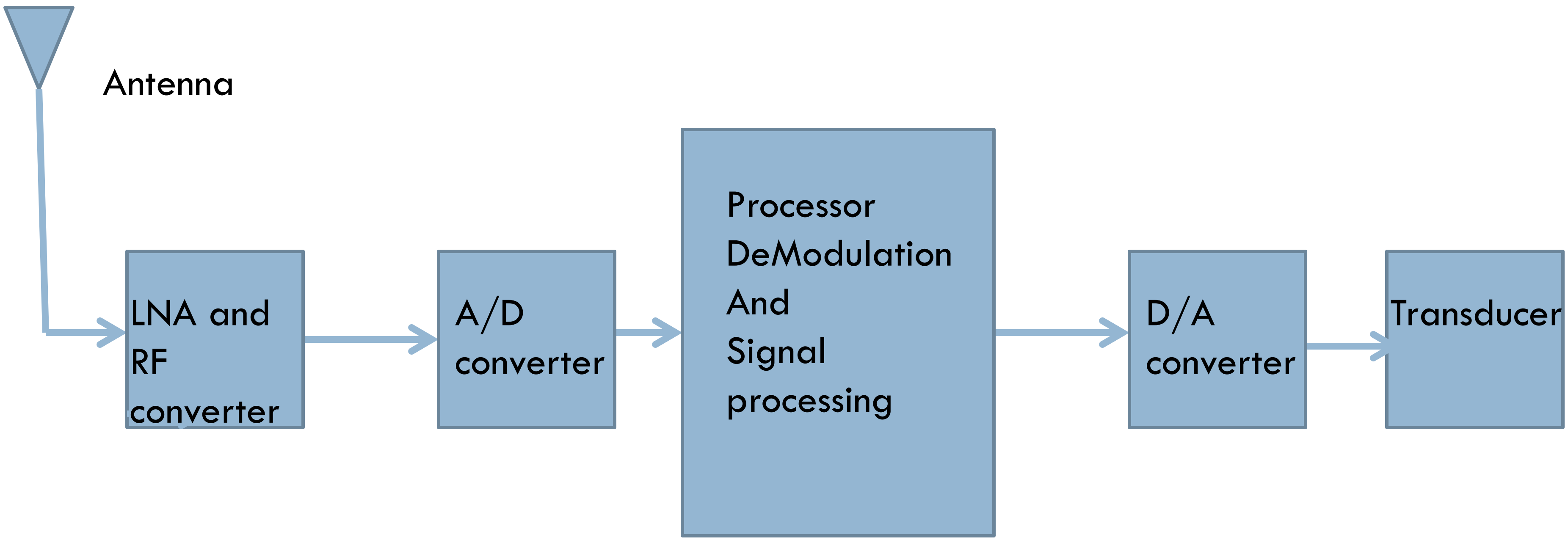
# Wireless Communication system



# Software defined radio Transmitter



# Software defined Radio Receiver



# Text book and references

- Digital Communications by

  Bernard Sklar
- Reference book

  Digital and analog communication systems

  By B.P.Lathi
- Resonant circuits and mixers

  Class notes