INTRODUCTION TO DIGITAL SIGNAL PROCESSING

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- What are signals?
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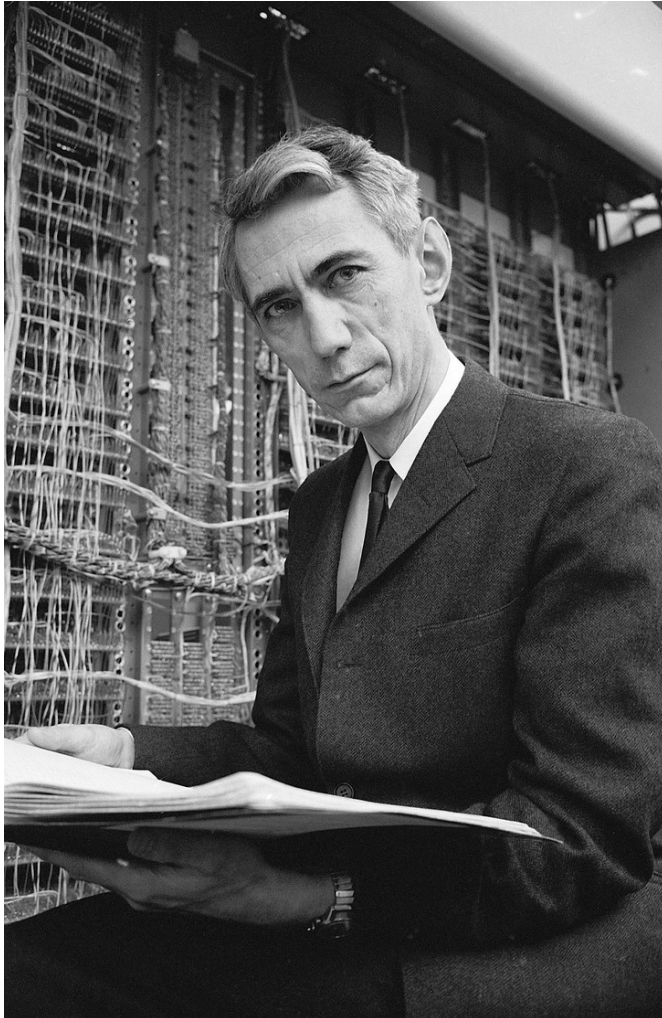- Conclusion
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Introduction

What is Signal Processing?

Signal processing is an extensive and very diverse field. Signal Processing is not the transmission or propagation of signals, but rather the changes made to the signals to improve the transmission and propagation of these signals.
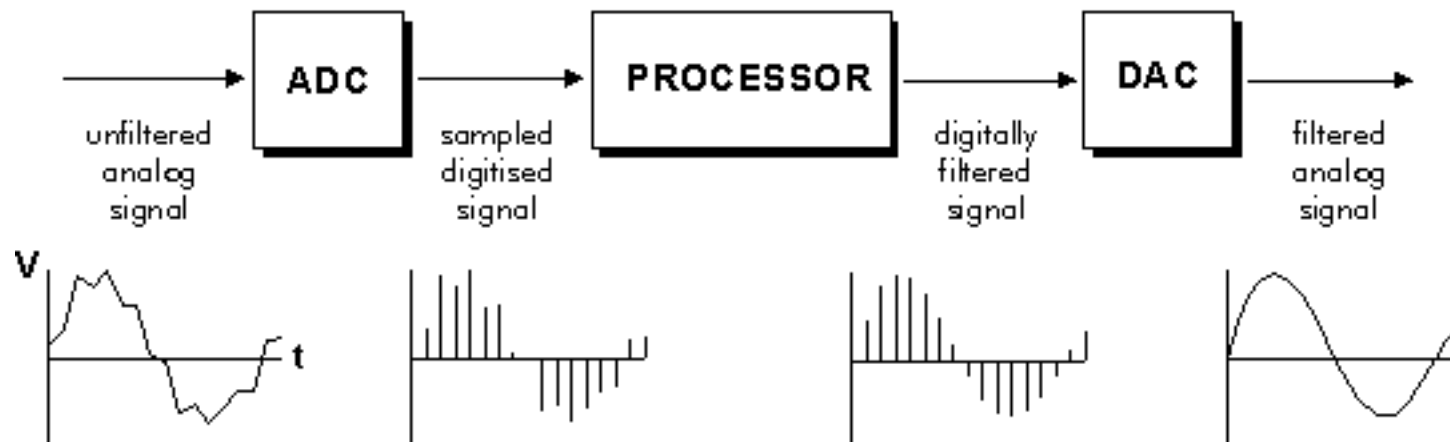
Conversion of signals

Background/History

Claude Shannon

Claude Elwood Shannon is considered as the founding father of electronic communications age. Shannon noticed the similarity between Boolean algebra and the telephone switching circuits, he applied Boolean algebra to electrical systems at the Massachusetts Institute of technology (MIT) in 1940. Later he joined the staff of Bell Telephone Laboratories in 1942. While working at Bell Laboratories, he formulated a theory explaining the communication of information and worked on the problem of most efficiently transmitting information. The mathematical theory of communication was the climax of Shannon's mathematical and engineering investigations. The concept of entropy was an important feature of Shannon's theory, which he demonstrated to be equivalent to a shortage in the information content (a degree of uncertainty) in a message.

Background/History

- 1950's

The 50's was the start of audio equipment such as the hi-fi and tape recorders.

- 1960's

Radar and Sonar was the ground breaking work of the 60's. Along with this was the. Improvement of telephones, satellite communication, the moon landing and coding schemes.

- 1970's

Digital Signal Processing originated in the 70's

- 1980's

The 80's saw the first personal computers from IBM and Apple, as well as CD's, Walkman's, cellphones and DSP chips. The 80's also created the DARPA Net.

- 1990's

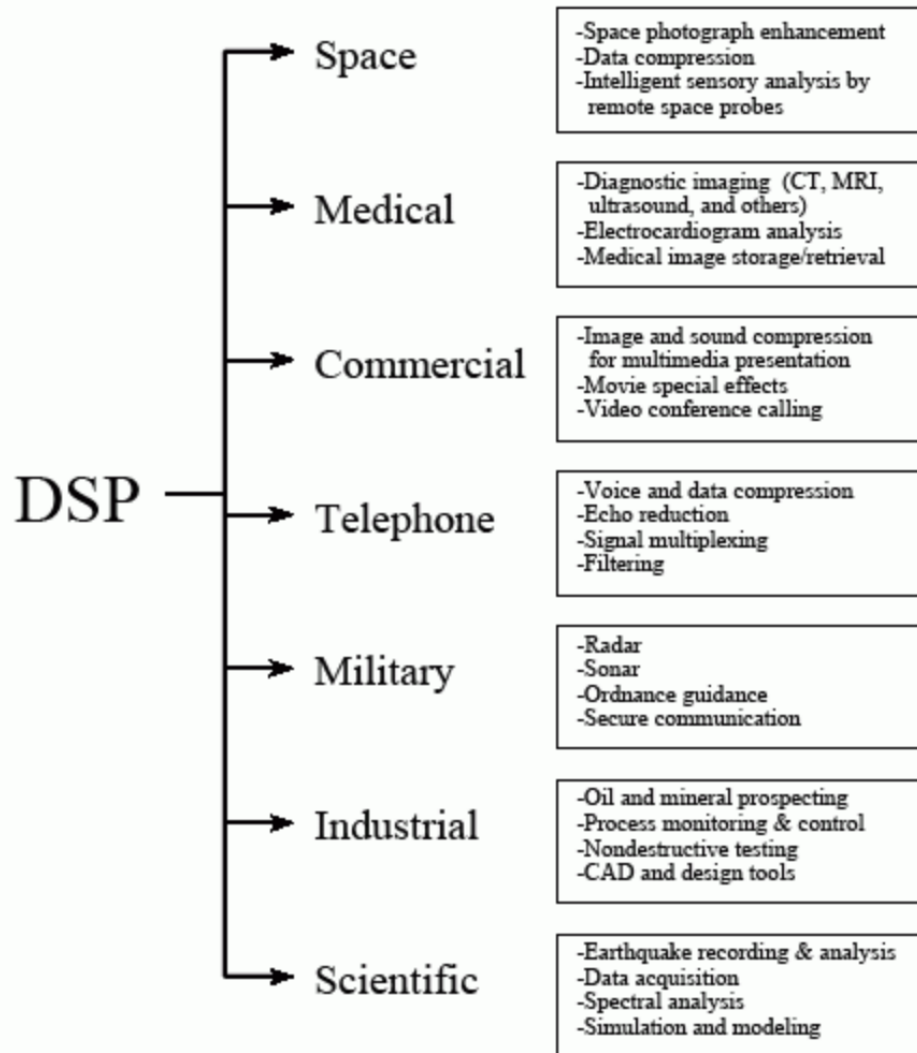The 90's created the interconnected network, HD formats and better DSP methods

- 2000's

The new millennium created neural networks for the use in parallel computing and aircraft.

- 2010's

In recent years signal processing has become a major part of our everyday life's.

Background/History

DSP

- **Space**
  - Space photograph enhancement
  - Data compression
  - Intelligent sensory analysis by remote space probes

- **Medical**
  - Diagnostic imaging (CT, MRI, ultrasound, and others)
  - Electrocardiogram analysis
  - Medical image storage/retrieval

- **Commercial**
  - Image and sound compression for multimedia presentation
  - Movie special effects
  - Video conference calling

- **Telephone**
  - Voice and data compression
  - Echo reduction
  - Signal multiplexing
  - Filtering

- **Military**
  - Radar
  - Sonar
  - Ordnance guidance
  - Secure communication

- **Industrial**
  - Oil and mineral prospecting
  - Process monitoring & control
  - Nondestructive testing
  - CAD and design tools

- **Scientific**
  - Earthquake recording & analysis
  - Data acquisition
  - Spectral analysis
  - Simulation and modeling

What are signals?

- A signal is something that represents information.
- A signal is usually a function of time that represents a physical variable

Examples of Signals:
- Audio
- Visual
- Biological
- Astronomy

Can you think of any more?
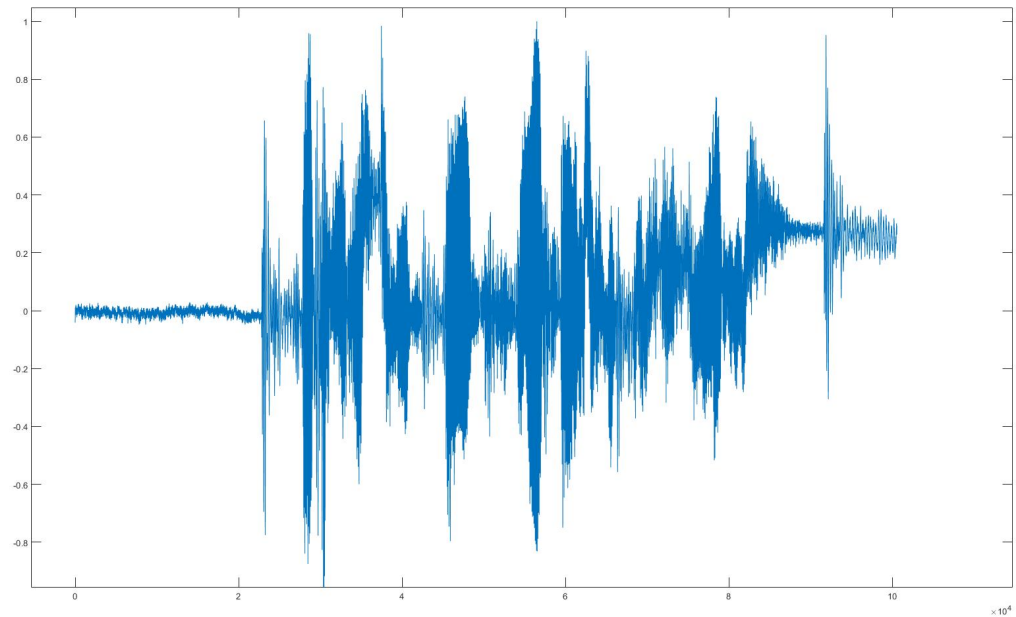
What are systems?

- A system is a generator of signals, or transforms signals.
- A system is a combination of interconnected components to perform a specific task.
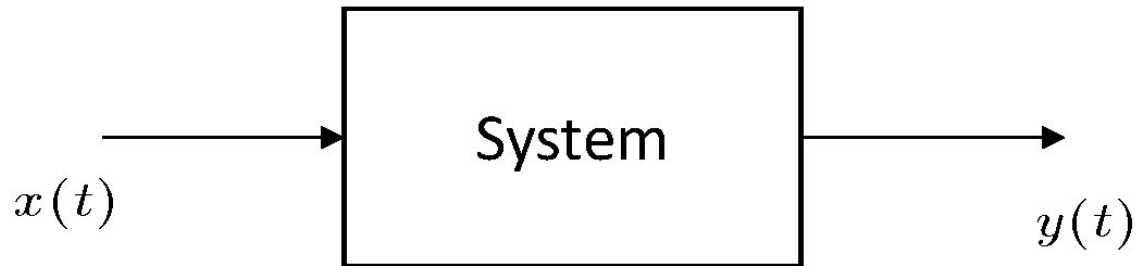
Examples of Signals:
- Mechanical
- Acoustic
- Electrical
- Astronomy

Can you think of any more?

* Model Systems
  Use mathematics to predict what the signals will do

* Analyze Systems
  How does the system affect signals.

* Design System
  Design a system to transform a signal in a certain way

* Test System
  Test the actual system

* Implement System
  Implement the actual system

$$x(t) \longrightarrow \boxed{\text{System}} \longrightarrow y(t)$$

Signals and Systems examples

Apache Attack Helicopter

Signals and Systems examples

Tesla Model 3 Autopilot

Signals and Systems examples

Falcon Heavy Side Boosters

Signals and Systems examples

HartRAO Radio Telescope

Signals and Systems examples
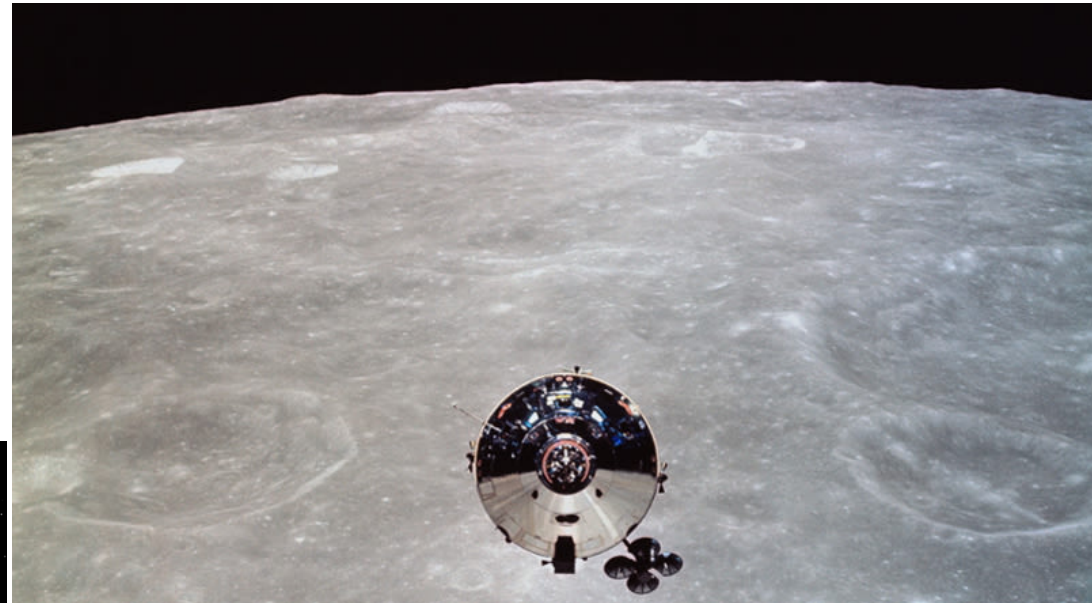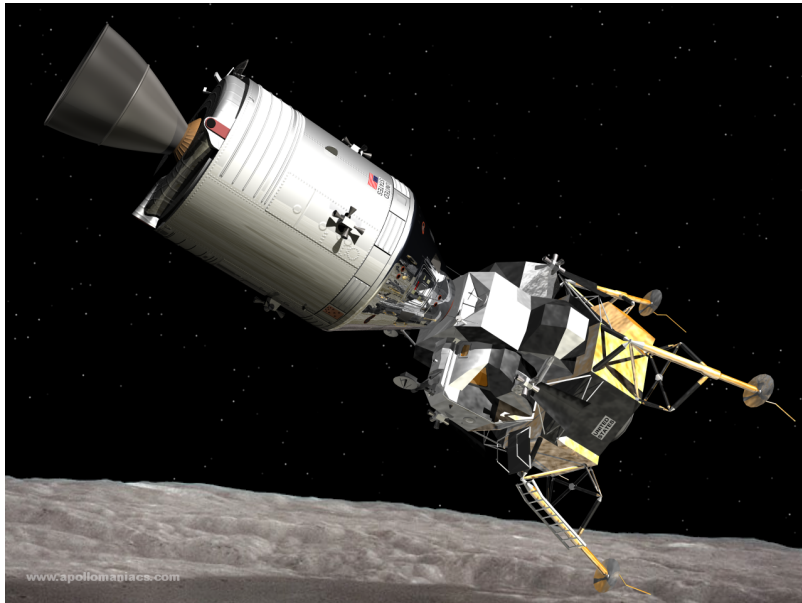
Tracking and Telemetry

Signals and Systems examples

Radio Astronomy VLBI Arrays

GLOBAL ARRAY

EVN

orbiting radio telescope

VLBA

Hartebeesthoek

AT-LBA
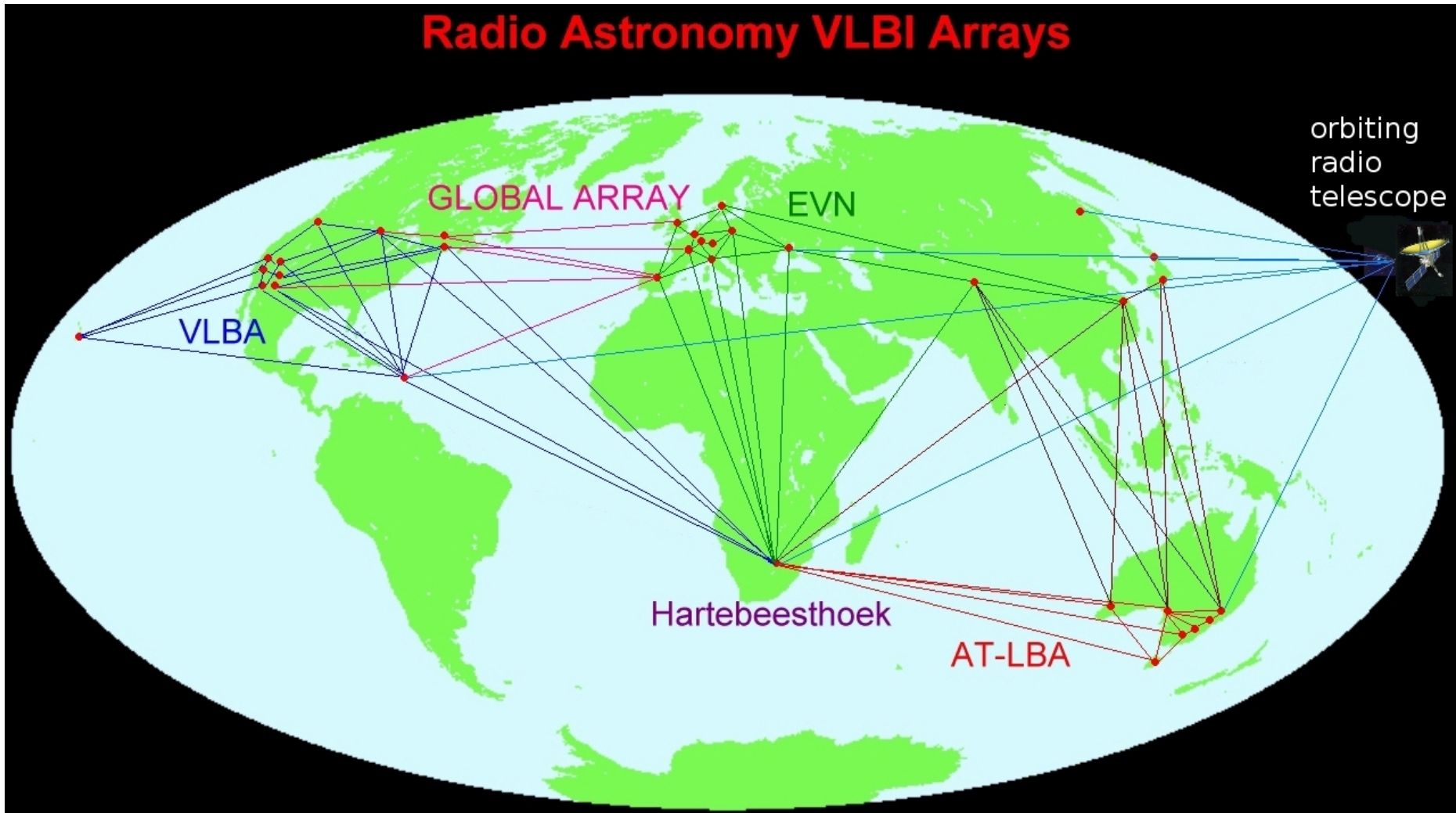
Signals and Systems Examples
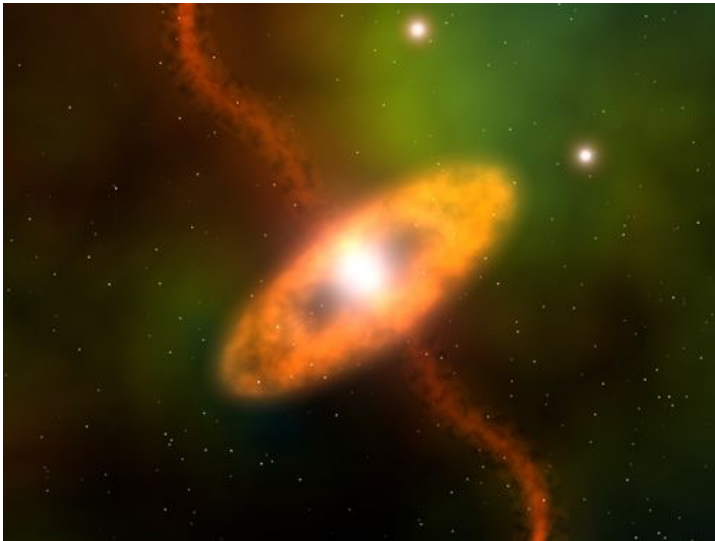
MASER Illustration
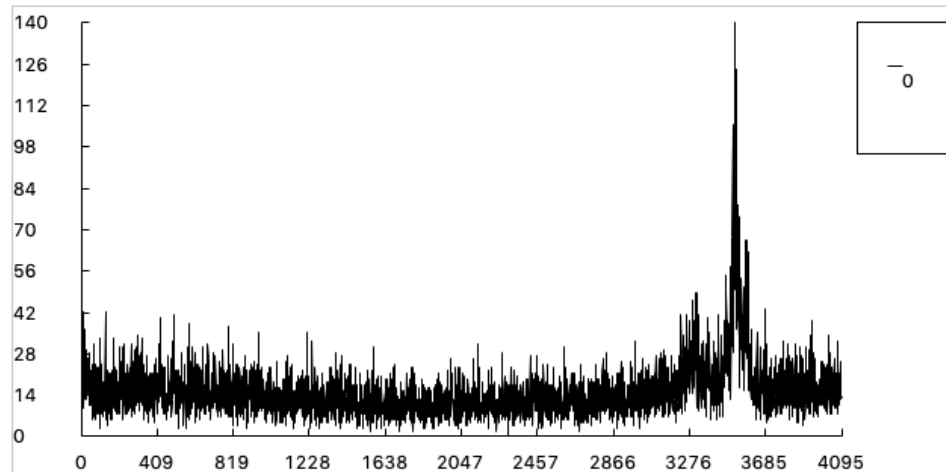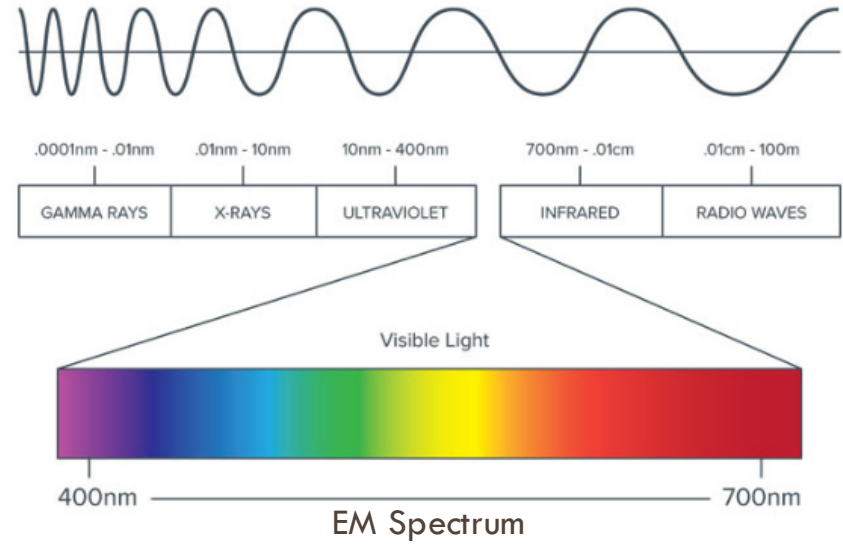
EM Spectrum

MASER Spectrum

Radio Telescope System

Celestial object

Filter

Spectrometer/pulsar timer/radiometer

Antenna

Amplifier and Attenuator

Signal Processing Libraries

Signal Processing

Output
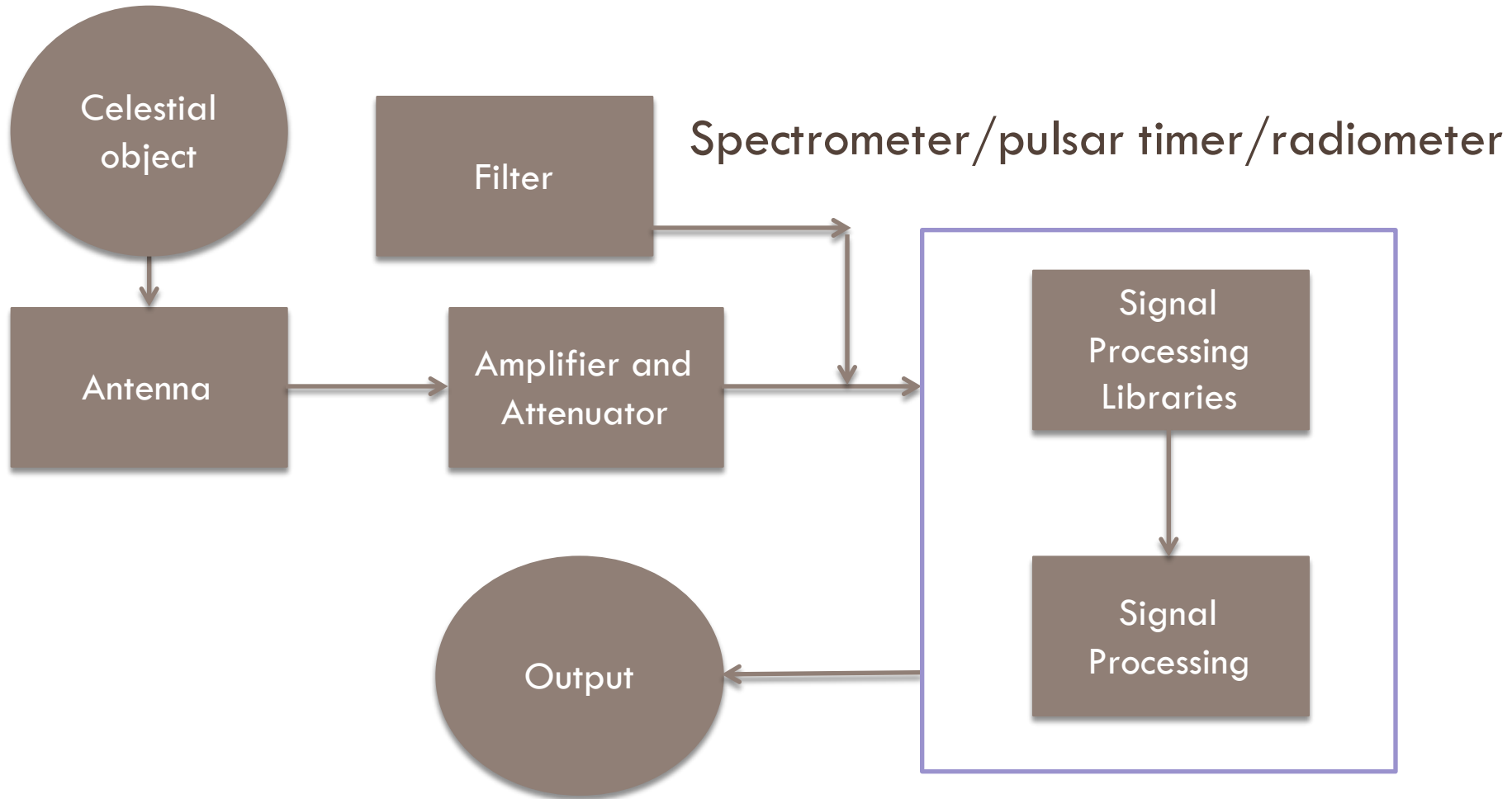
Signal Properties

Deterministic Signals

Deterministic signals are signals that can be modeled completely as a specified function in time

$$x(t) = e^{-0.5t}\sin(3t+1)$$
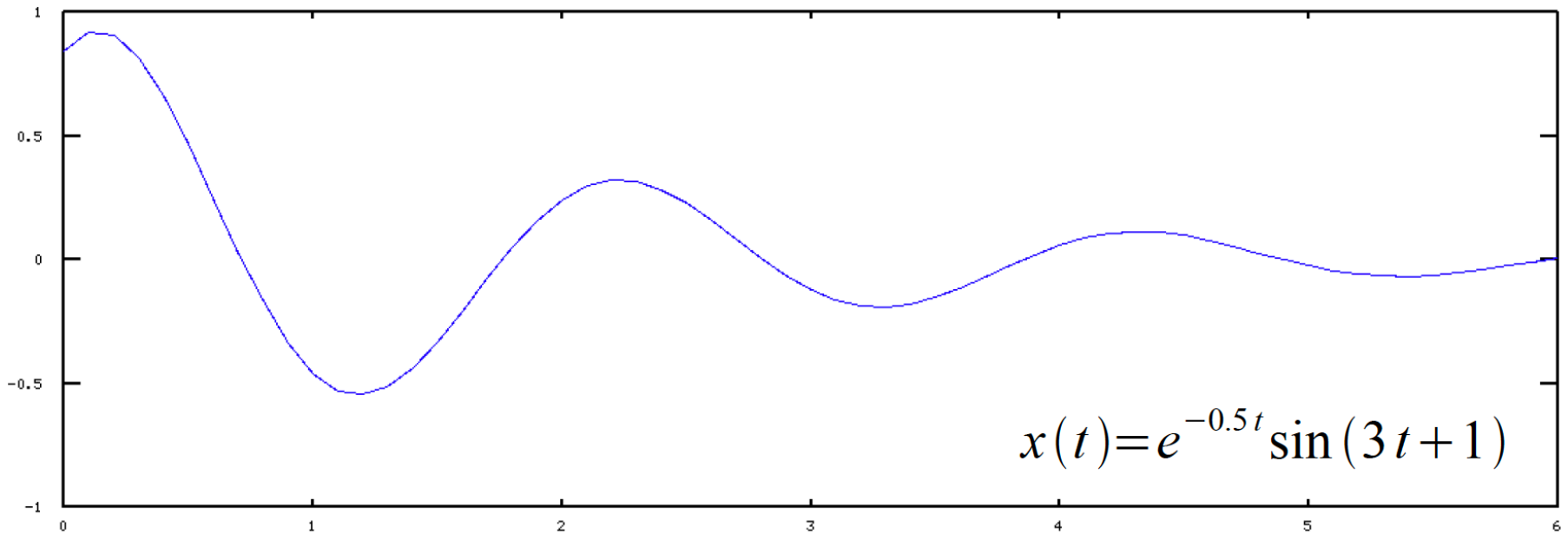
Deterministic Signal

Signal Properties

Random Signals

Random signals take on random values at any time given time.

Random Signal
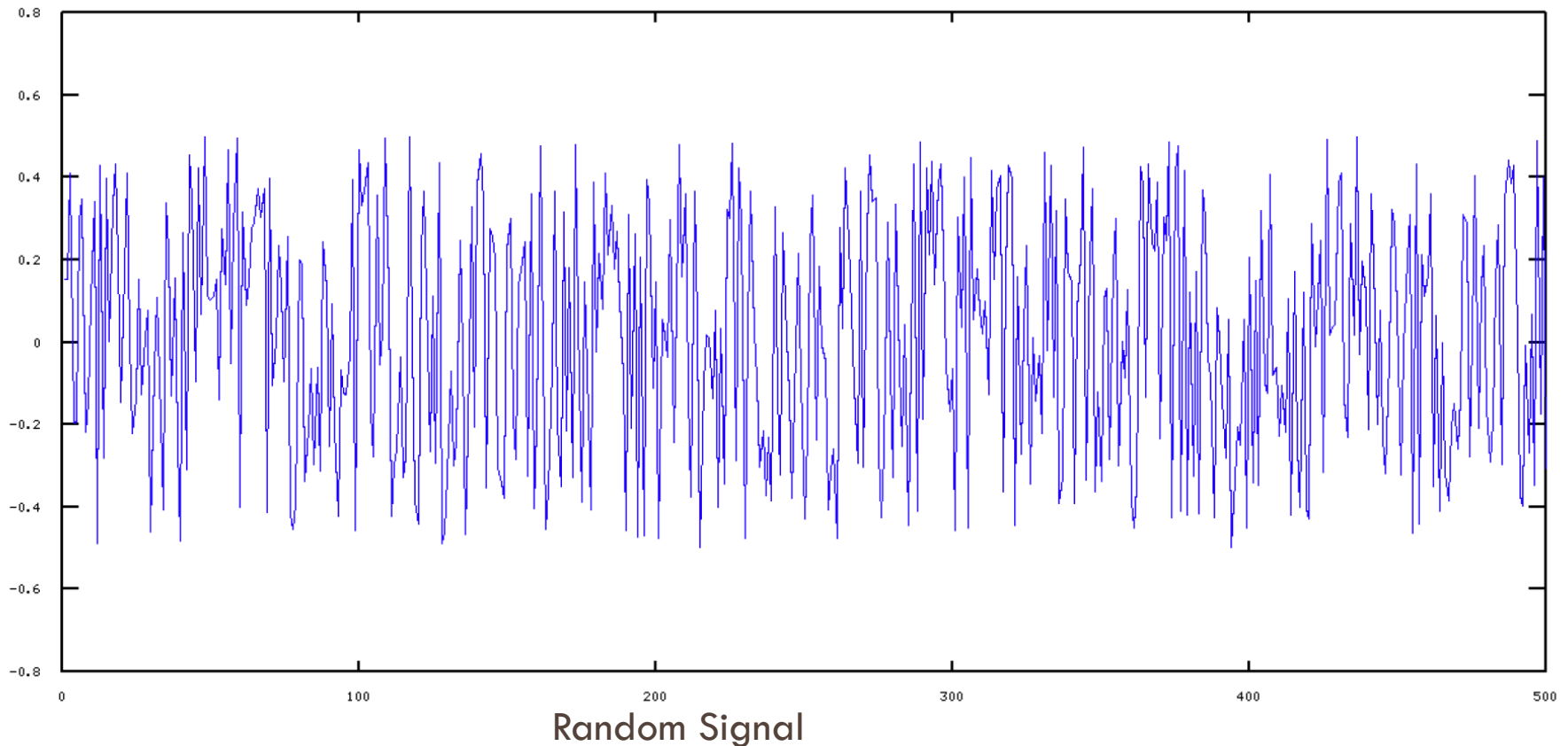
Signal Properties

Continuous-time Signal

A   Continuous-time Signal has a value specified for all points in time
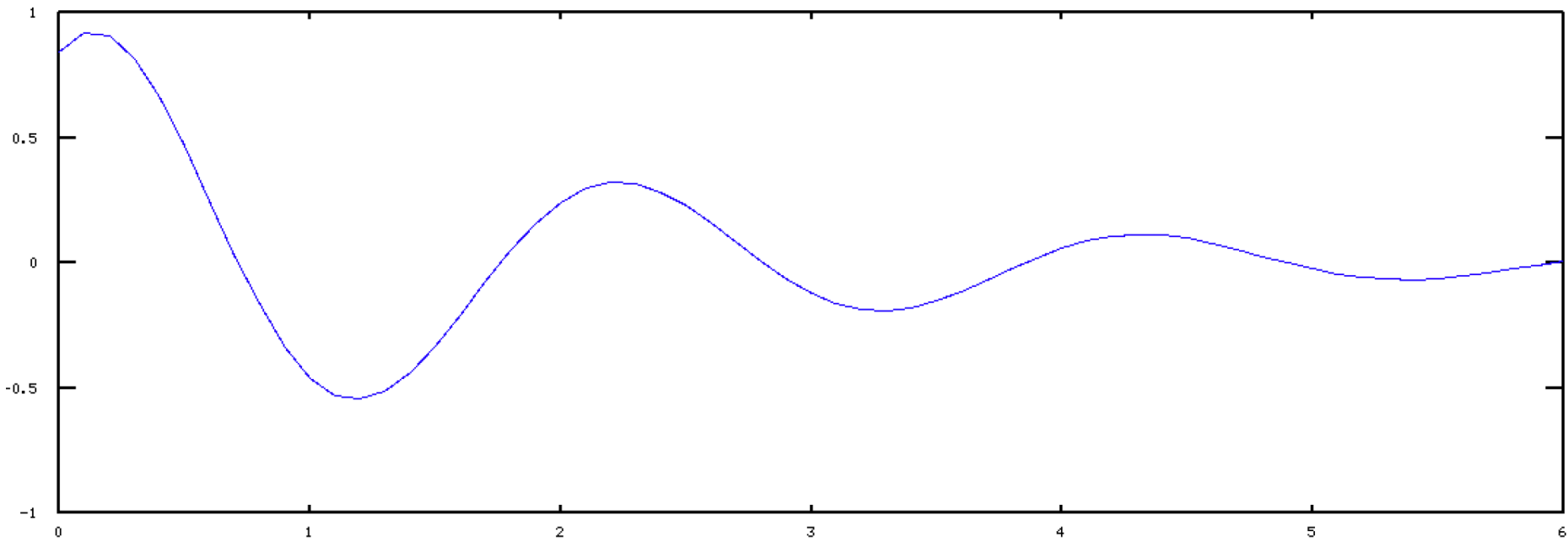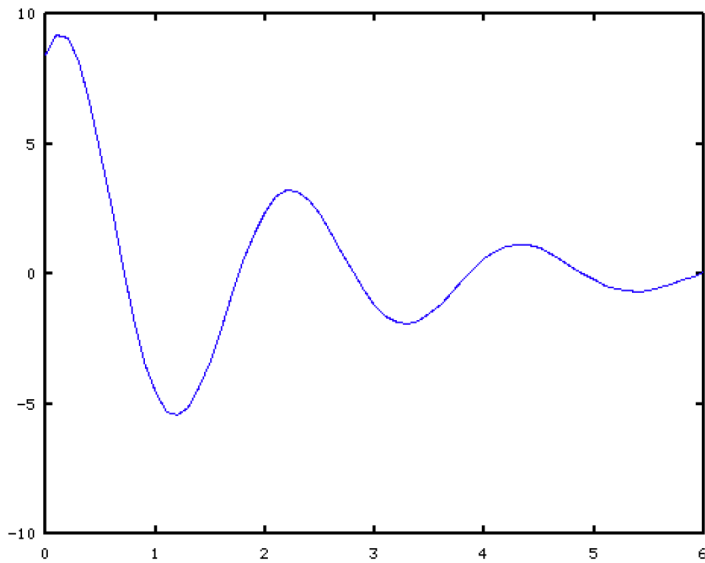

Continuous-time Signal

Signal Properties

Discrete-time Signal

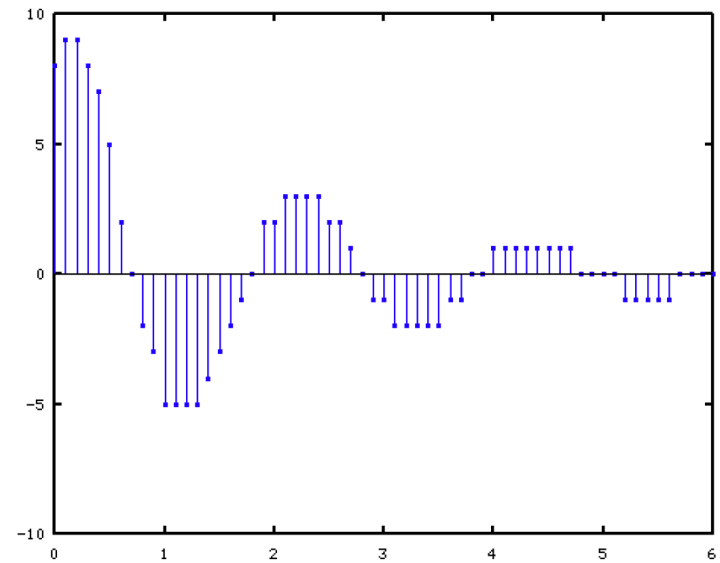A   Discrete-time Signal has a value specified only at certain (discrete) points in time

Discrete-time Signal
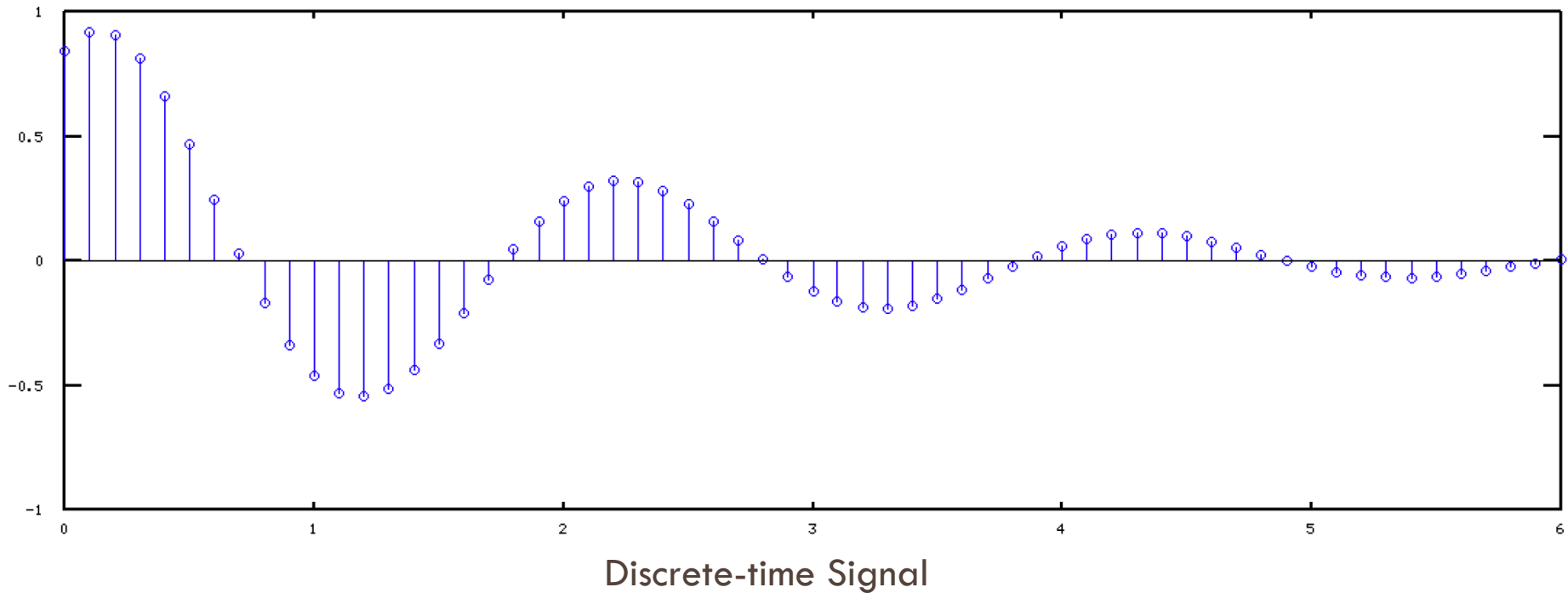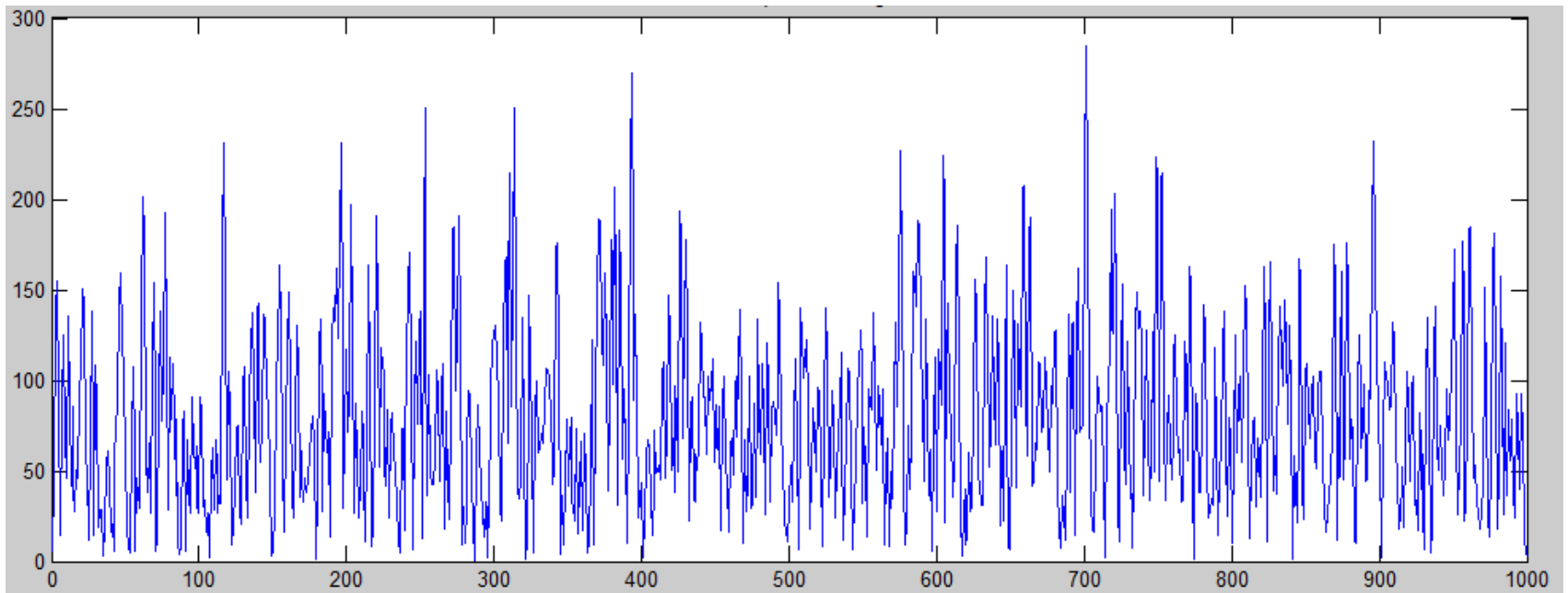
Signal Properties

Analog and Digital Signals
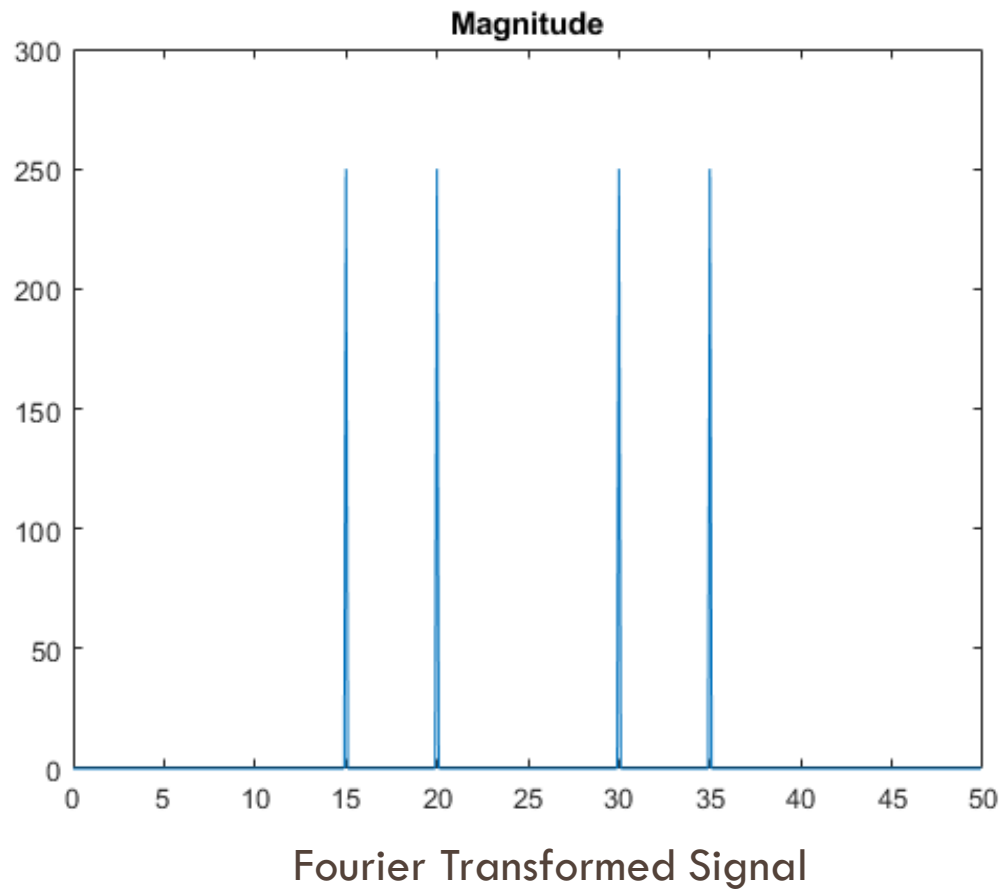

Analog Signal

Digital Signal

Signal Properties

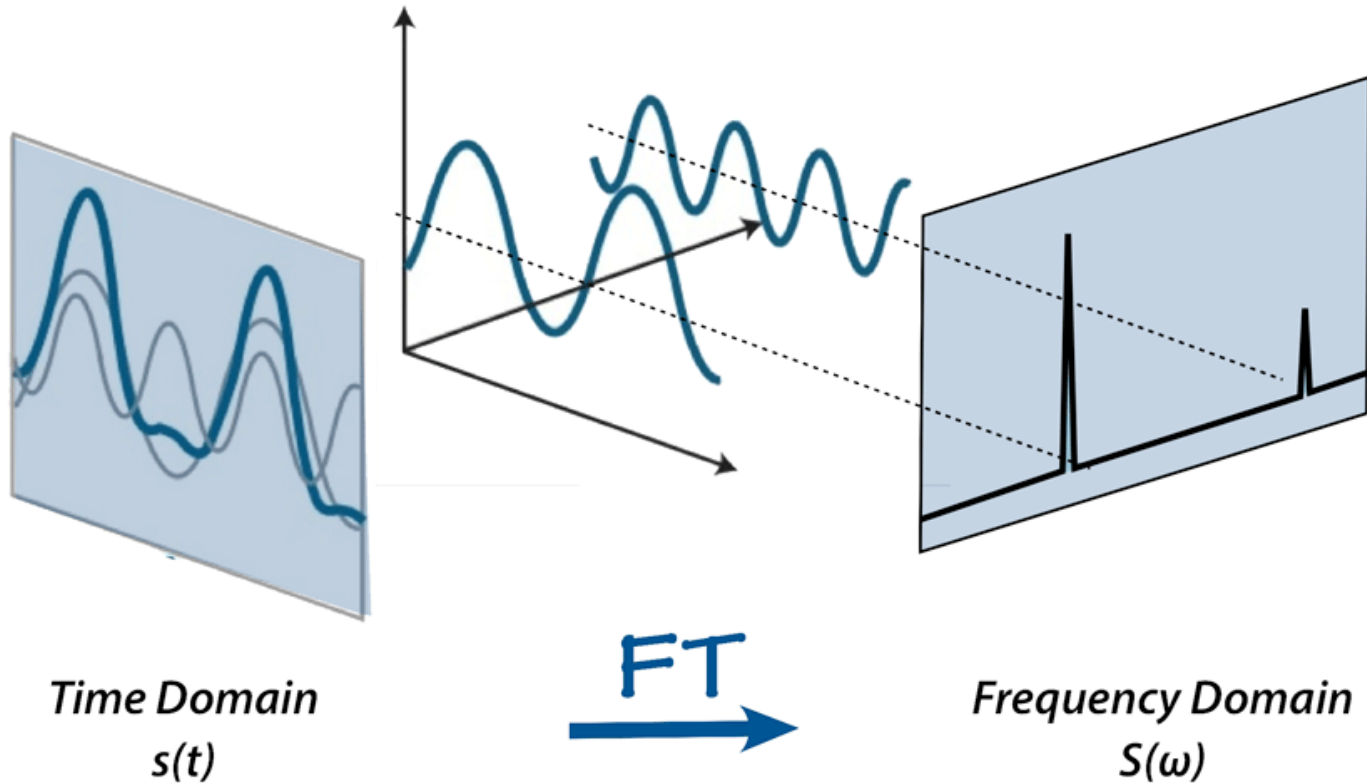The Fourier Transform

Mixed Signals
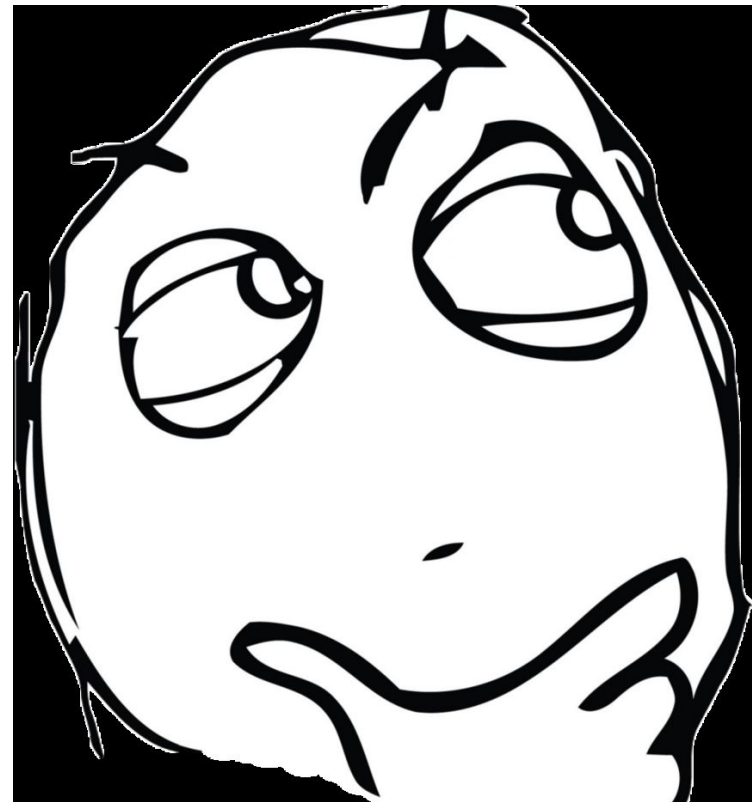
Signal Properties

The Fourier Transform

Fourier Transformed Signal

Signal Properties

The Fast Fourier Transform (FFT)

Time Domain
s(t)

FT

Frequency Domain
S(ω)

Conclusion

Where is this leading?

Conclusion

Where is this leading?

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Conclusion

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Questions