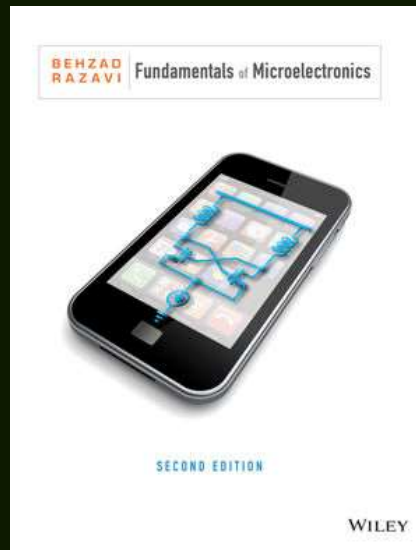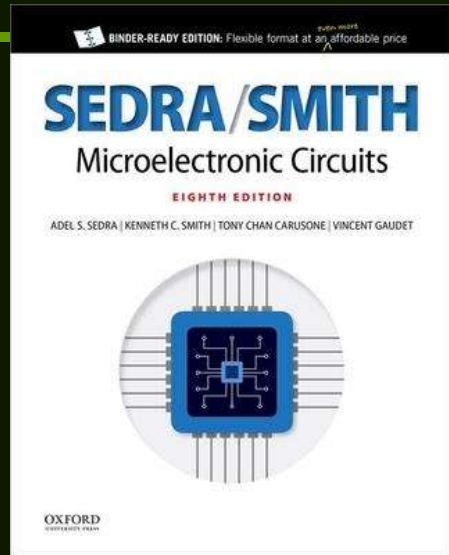Week1 Electronics1

Introduction

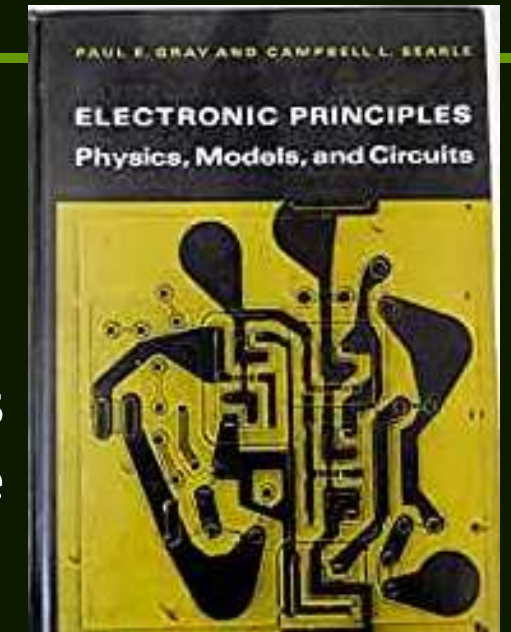**Fundamentals of Microelectronics, 2nd Edition, 2013**
Behzad Razavi

تحلیل و طراحی مدارهای مجتمع آنالوگ- جلد اول (ترانزیستورهایBipolar)
تحلیل و طراحی مدارهای مجتمع آنالوگ- جلد دوم (مدارهای cmos)
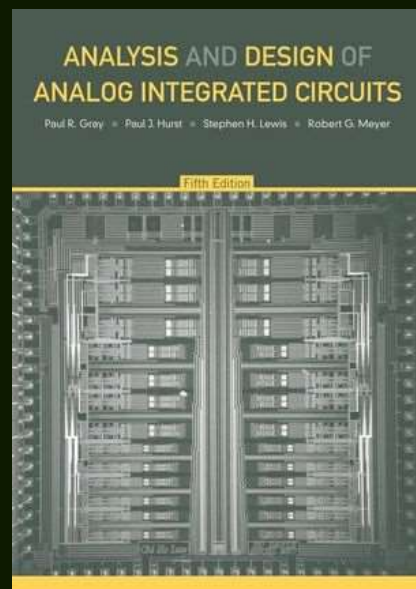مولفان: دکتر مهرداد شریف بختیار
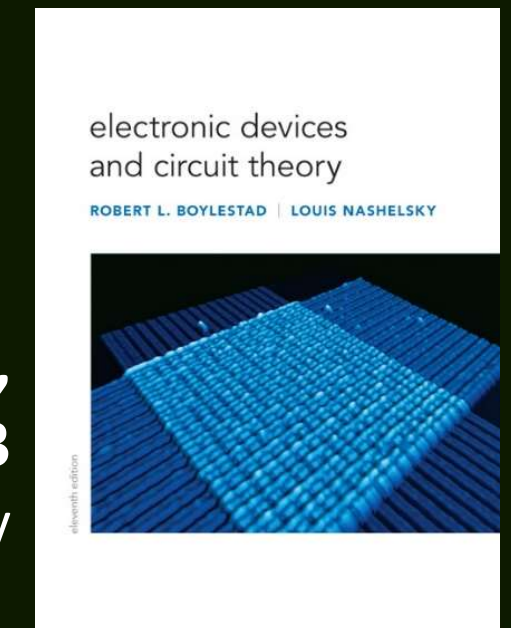
Introduction – Other Text Books

Microelectronic Circuits, Eighth Edition, 2020

Sedra, Smith, Carusone, Gaudet

Electronic Principles: Physics, Models and Circuits

Paul E Gray, Campbell L. Searle

Analysis and Design of Analog Integrated Circuits, 5th Edition, 2009

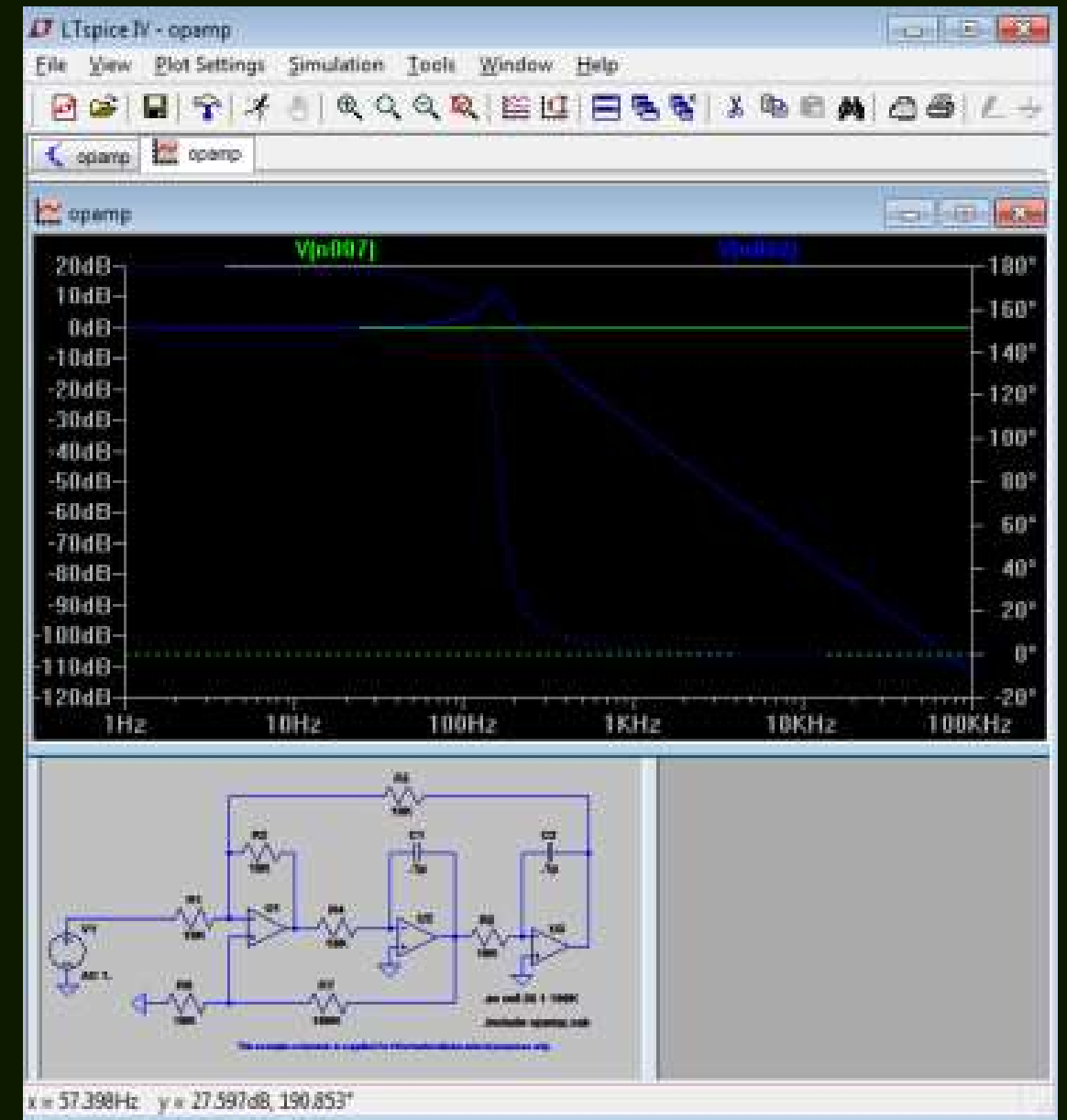Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer

Electronic Devices and Circuit Theory, 11th Edition, 2013
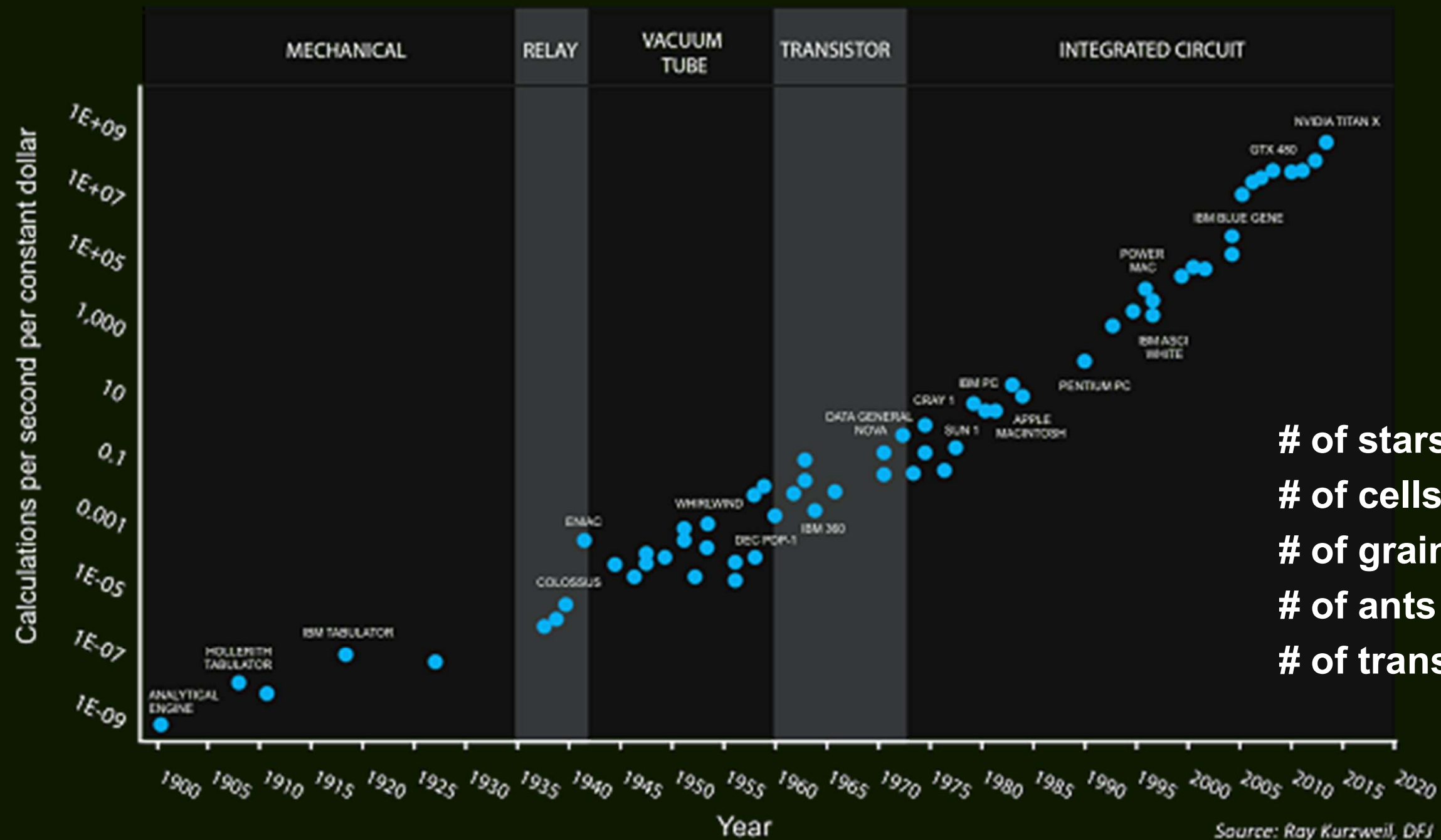
Robert L. Boylestad, Louis Nashelsky

LTSPICE

SPICE (Simulation Program with Integrated Circuit Emphasis)
a general-purpose circuit simulator

http://www.linear.com/designtools/software/#LTspice

Microelectronics, Nanoelectronics

120 Years of Moore's Law

# of stars in milky way = 10^{11}
# of cells in body = 10^{14}
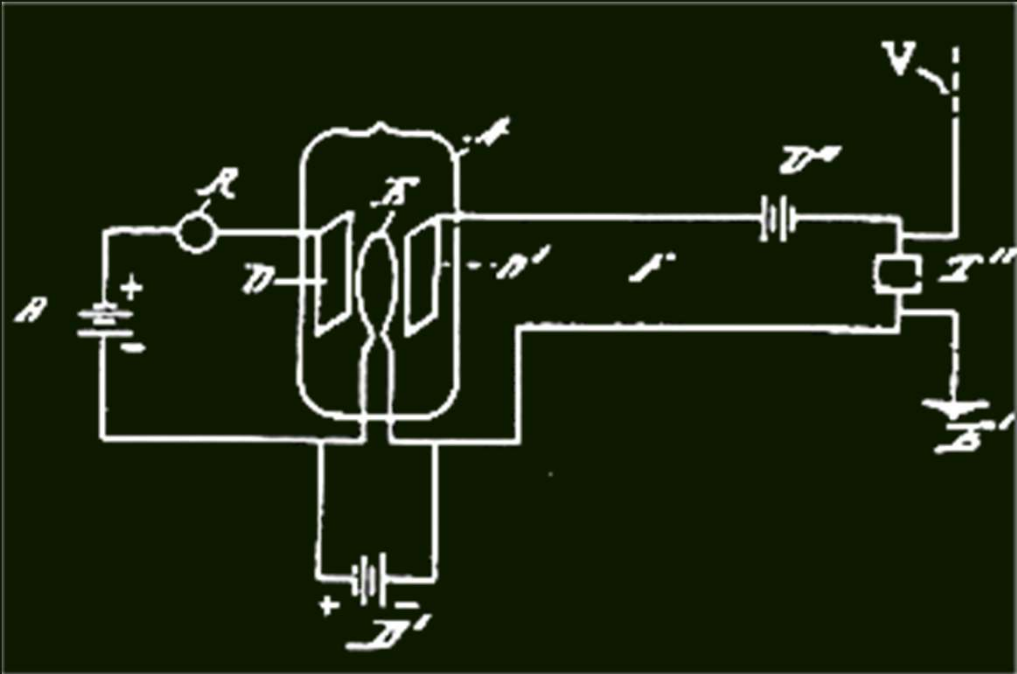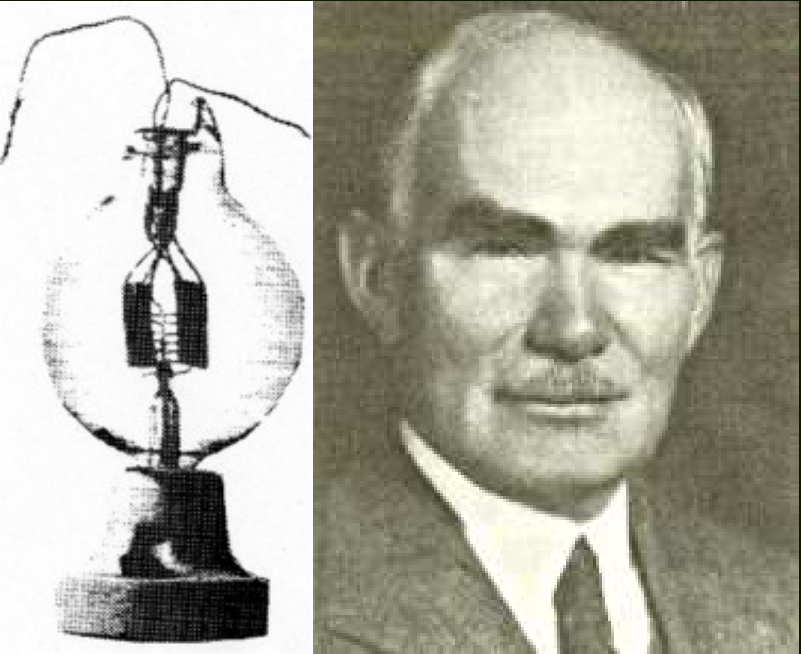# of grains of rice = 10^{16}
# of ants = 10^{17}
# of transistors = 10^{20}

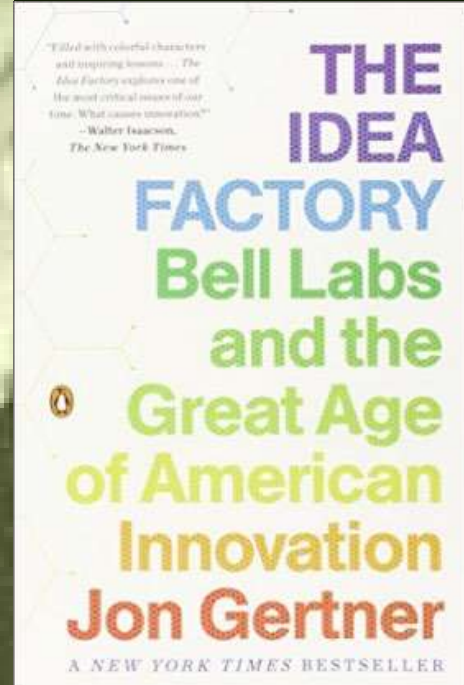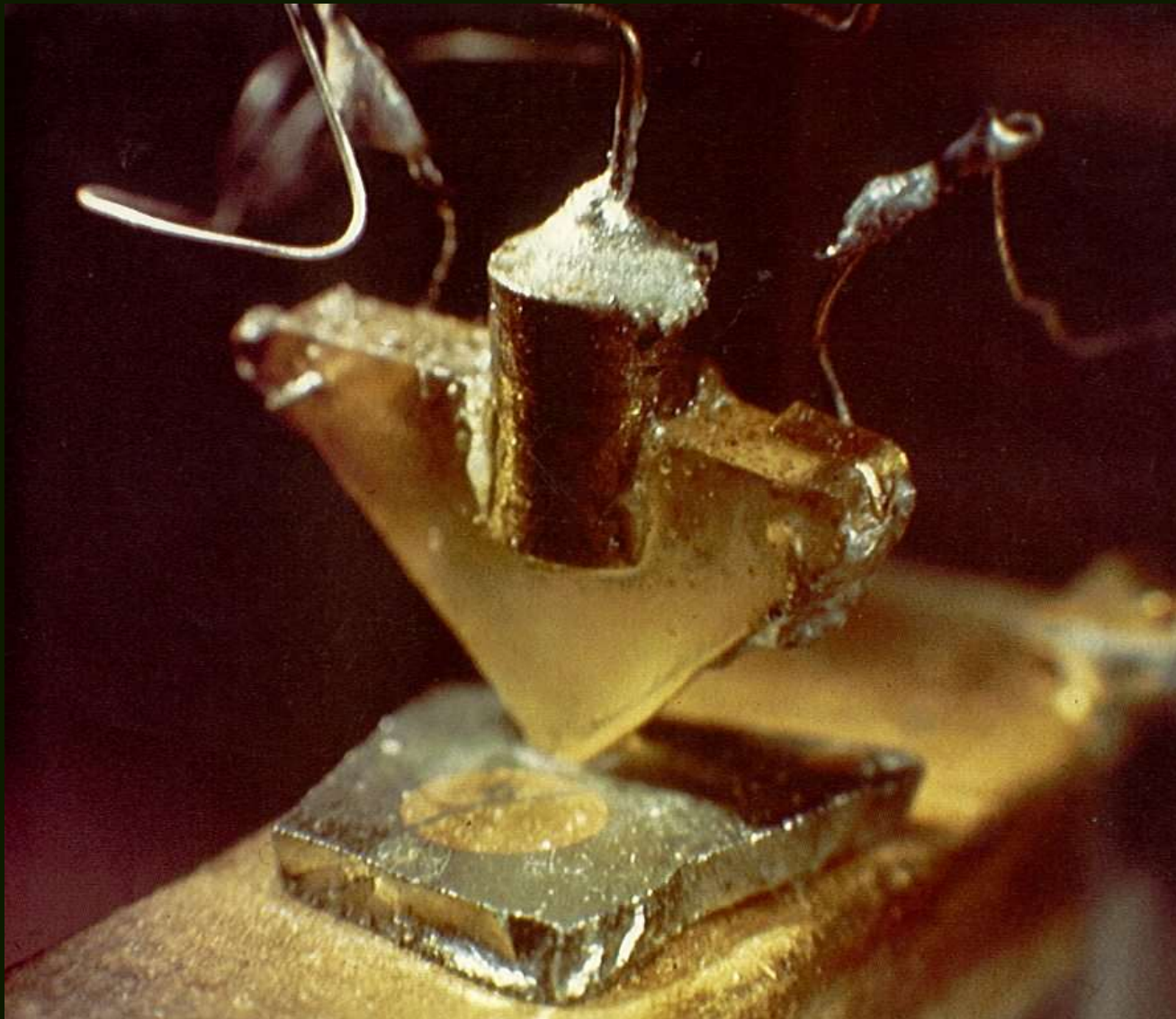Source: Ray Kurzweil, DFJ

(1906) Vacuum Tube : Triode

Lee De Forest (1873 –1961)

The 1946 ENIAC computer used 17,468 vacuum tubes and consumed 150kW of power
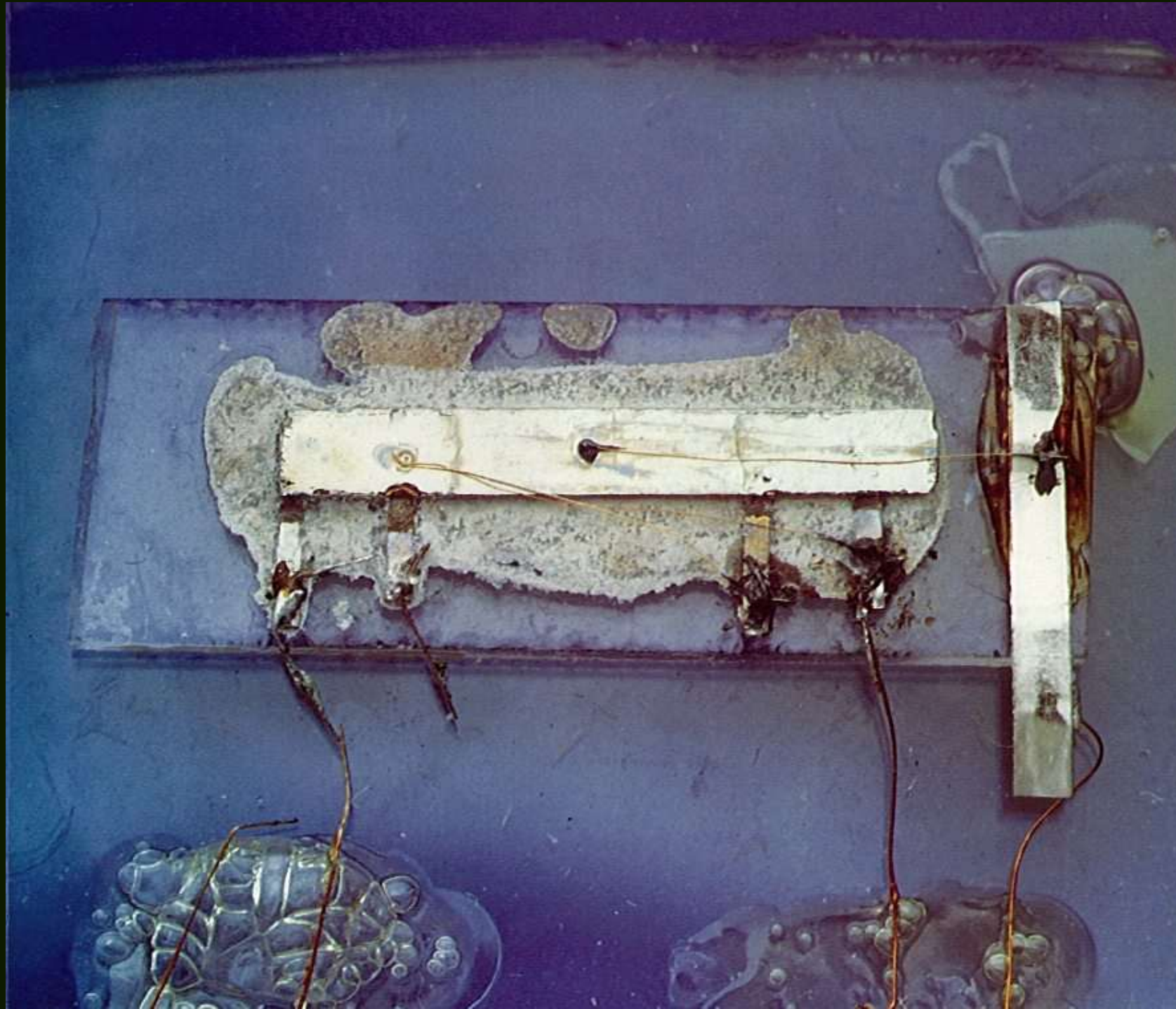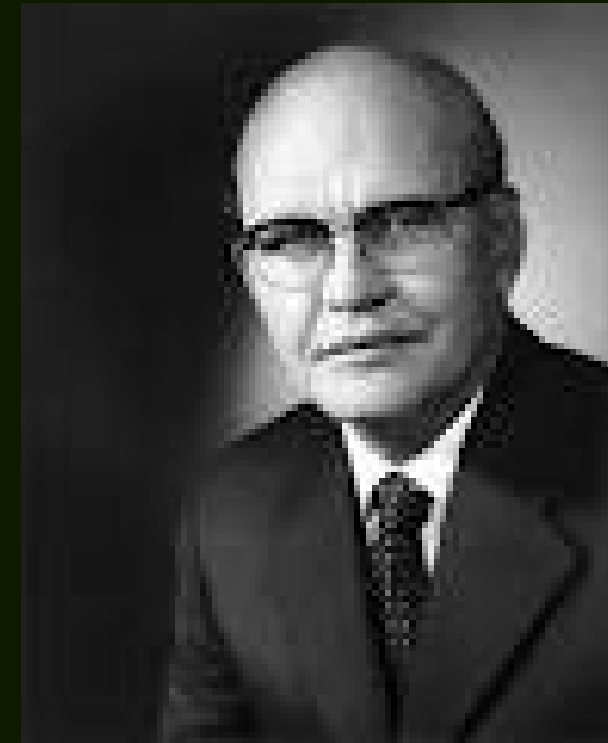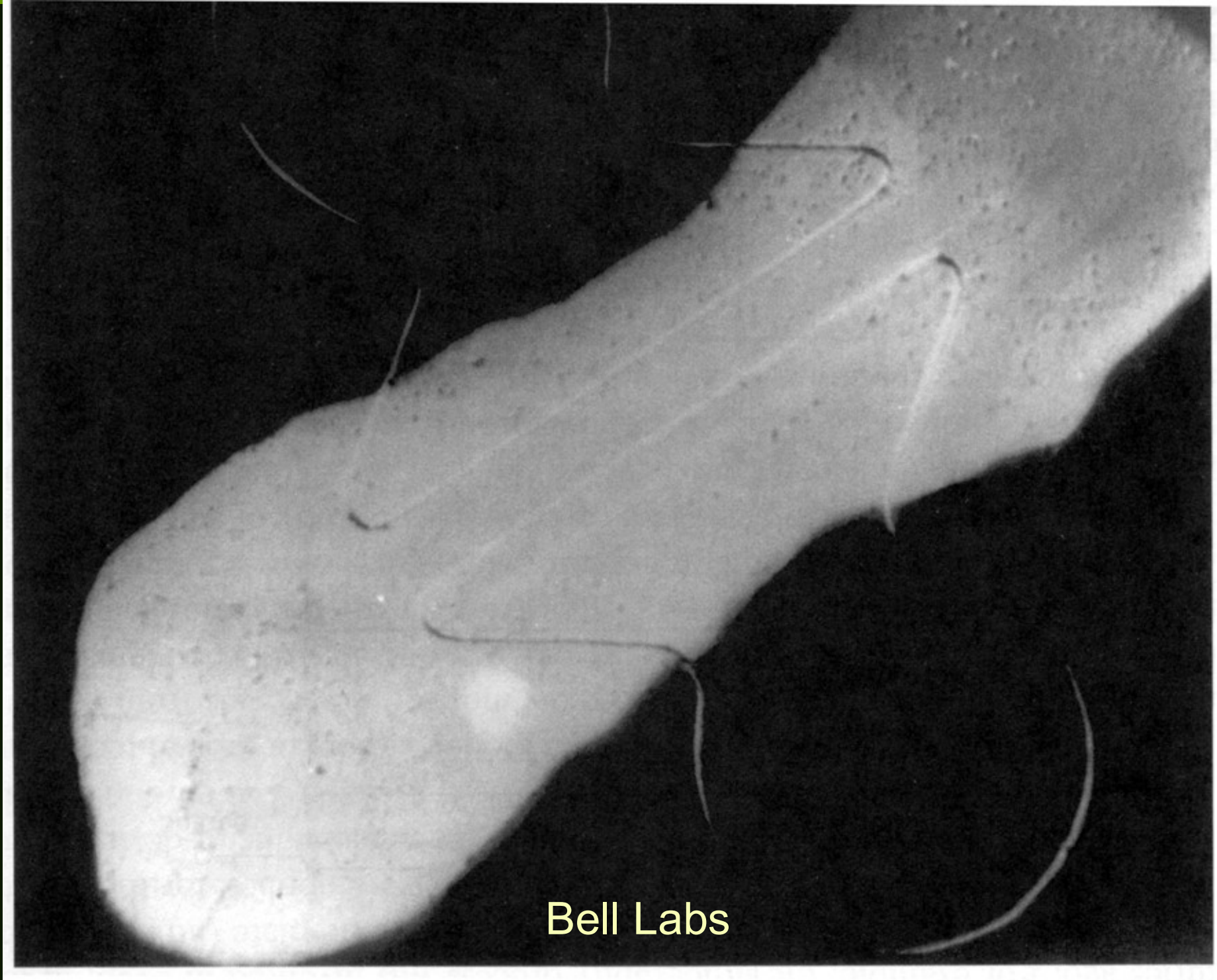
Bell Labs, 1948

J. Bardeen, W. Brattain, W. Shockley

1958, Kilby, Texas Instruments

Jack St. Clair Kilby
(1923 – 2005)

1960, MOSFET, D. Kahng and M. Atalla

Bell Labs

In Billion $s!

	GDP at market prices	Value of exports	Value of petroleum exports
Iran	387.6	77.9	27.3
Saudi Arabia	653.2	205.4	157.9
Qatar	166.4	77.2	28.3
Venezuela	239.5	38.0	35.8

	Revenue	Income	Total assets
IBM	81.7	15.9	110.4
intel	55.3	14.2	101.4
SAMSUNG	305	22.1	529.5
QUALCOMM	25.3	5.8	50.8
Apple	215.6	60.0	321.6

AMD Ryzen 9 3900X

Core i9-10900X

7 nm, 12 nm

4.3 GHz

9.89 billion transistors

206.1 mm2

14nm

3.7 GHz

~ 10 billion transistors?!

iPhone 11

iPad Air

A13

A14

7 nm FinFET

8.5 billion

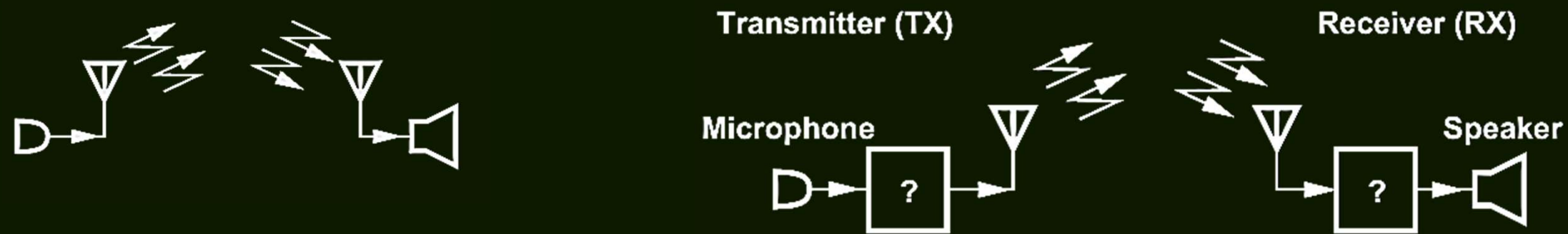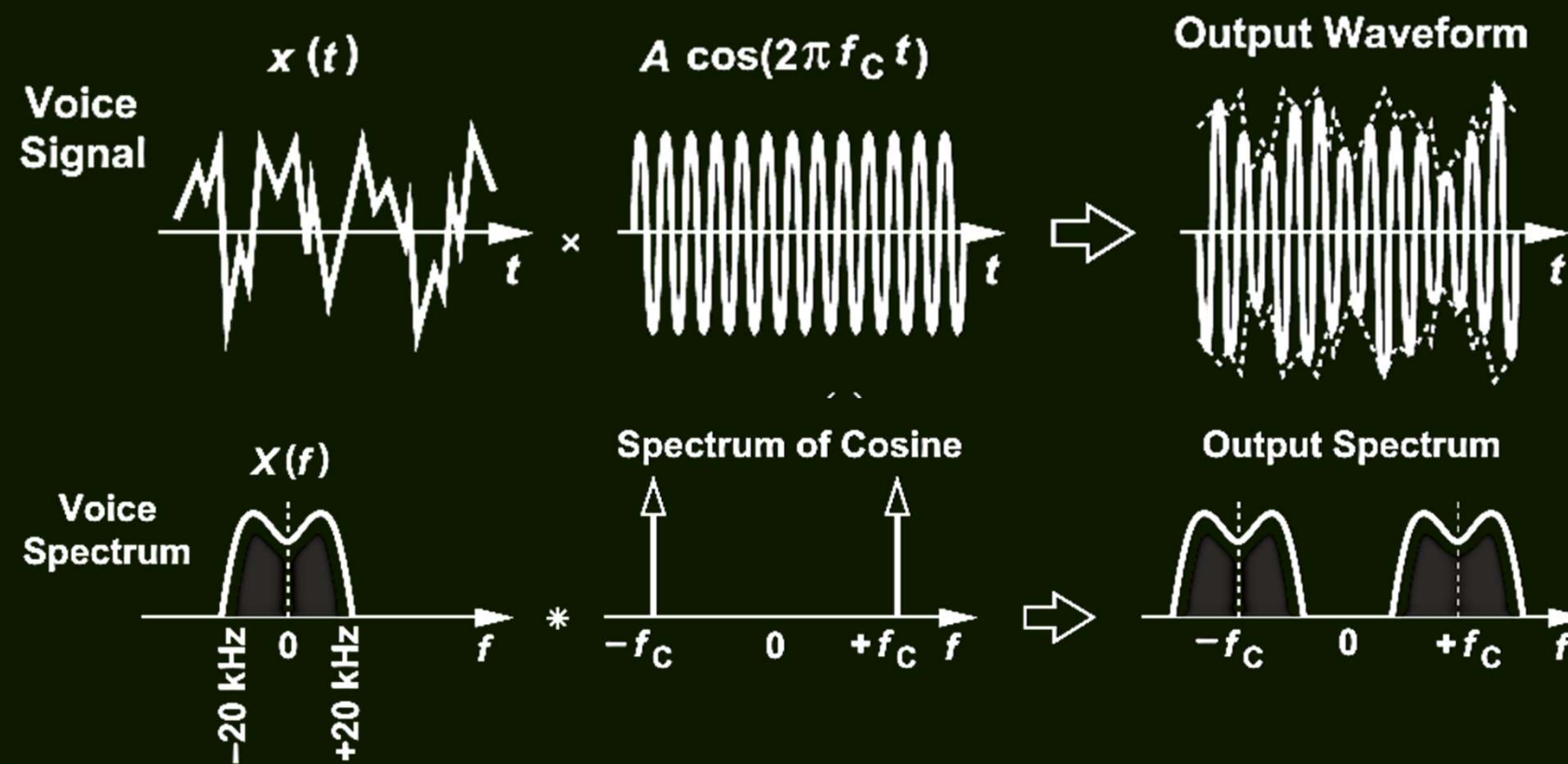2.65 GHz

5 nm FinFET

11.8 billion

98.48 mm2

11

Cellular Phone

Transmitter (TX)　　　　　Receiver (RX)

Microphone　[?]　　　　　[?]　Speaker

Microelectronics exist in black boxes that process the received and transmitted voice signals

Voice Signal $x(t)$　×　$A \cos(2\pi f_C t)$　⟹　Output Waveform

Voice is "up-converted" by multiplying two sinusoids

Voice Spectrum $X(f)$　−20 kHz　0　+20 kHz　*　Spectrum of Cosine　$-f_C$　0　$+f_C$　⟹　Output Spectrum　$-f_C$　0　$+f_C$

When multiplying two sinusoids in time domain, their spectra are convolved in frequency domain
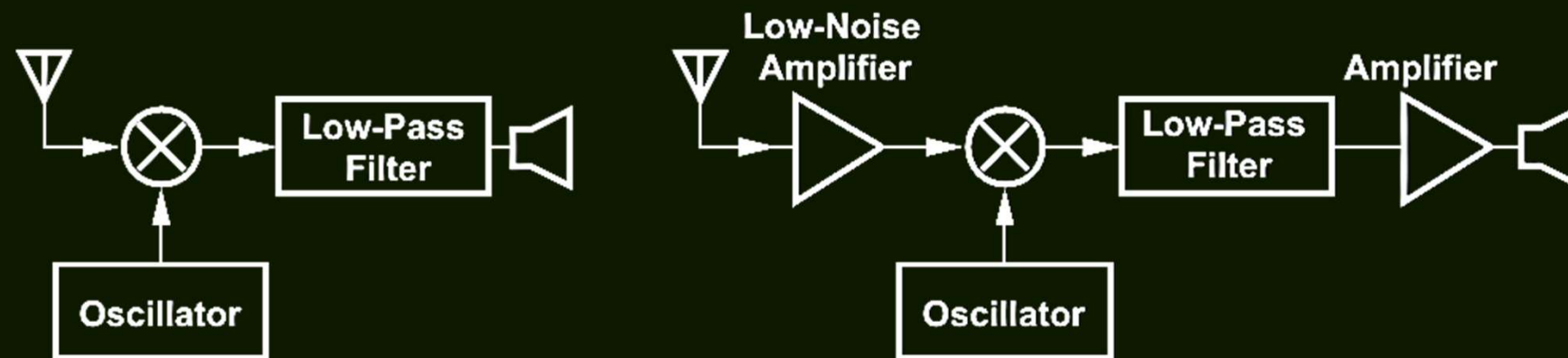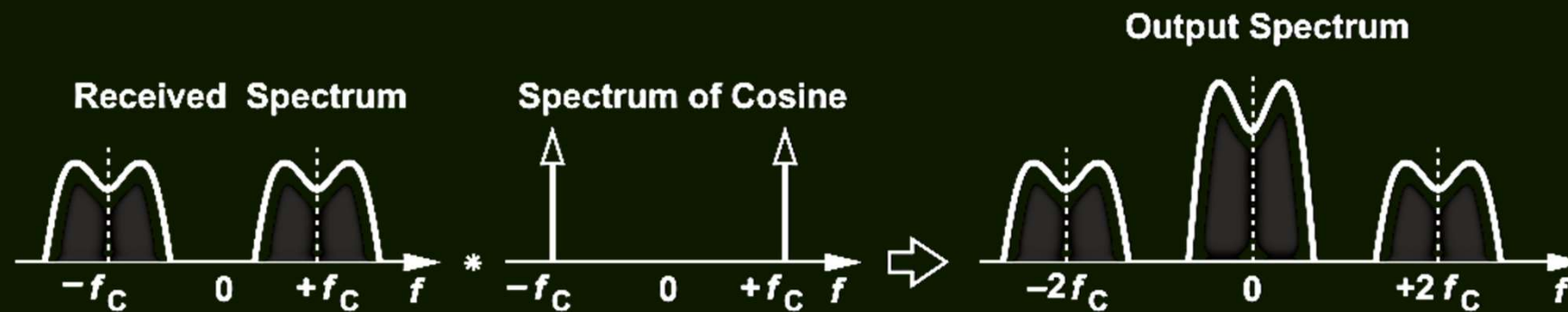
12

Two frequencies are multiplied and radiated by an antenna
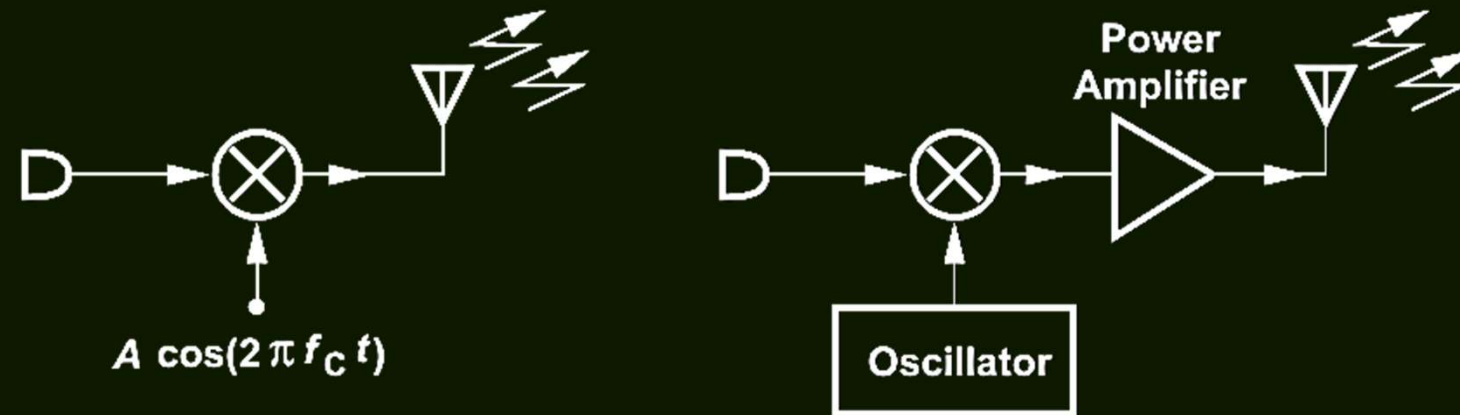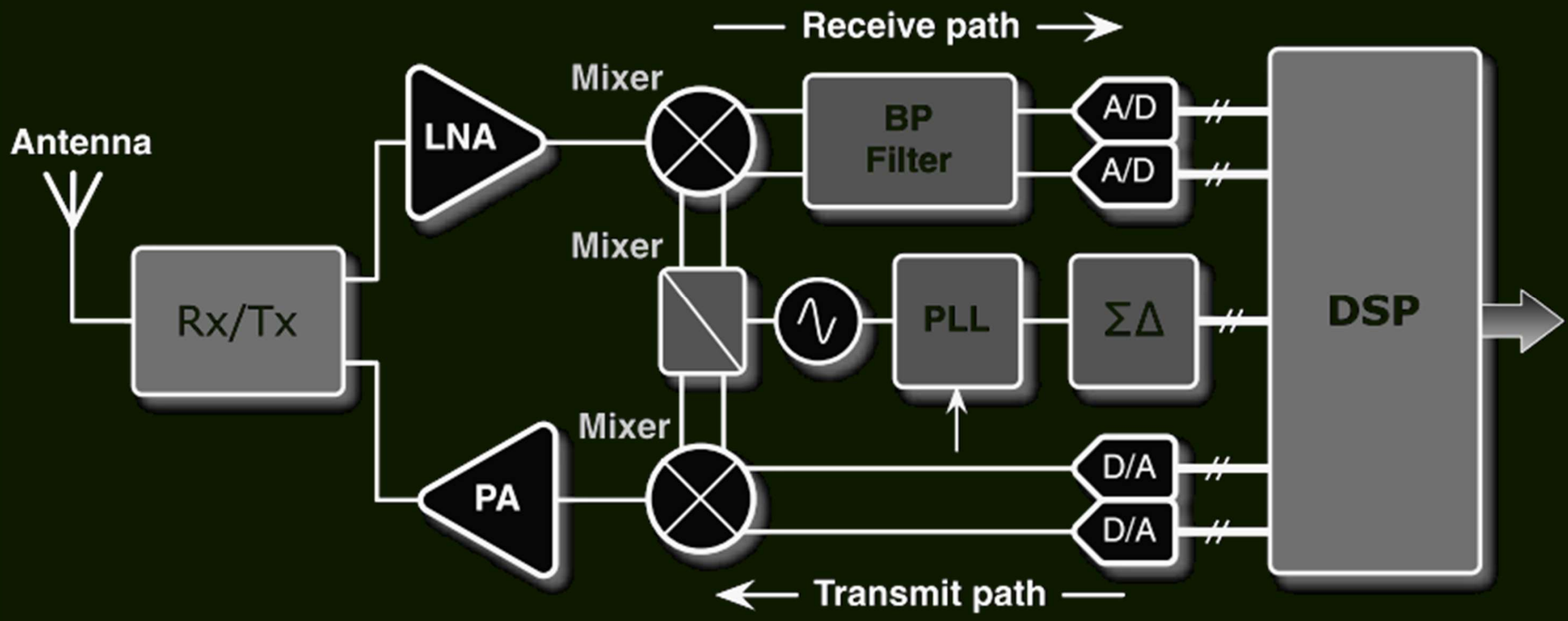
A power amplifier is added to boost the signal.

High frequency is translated to DC by multiplying by f_C

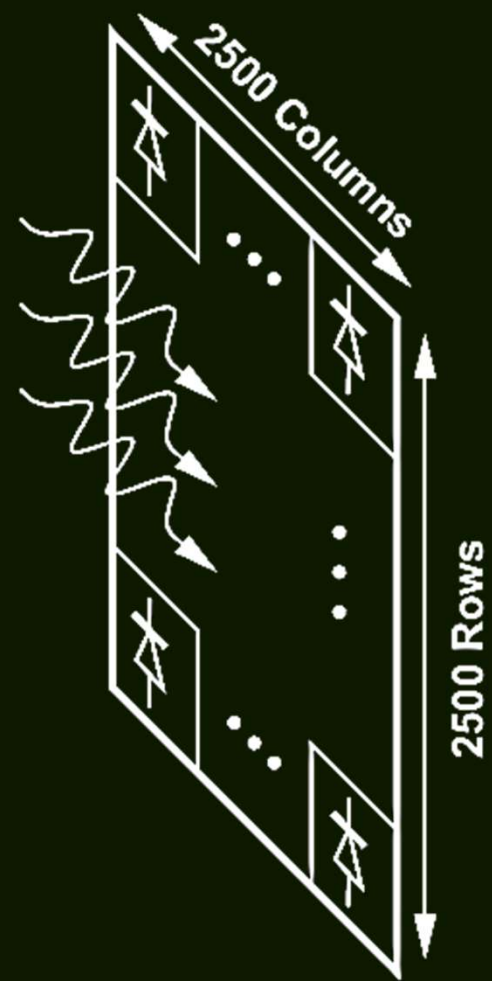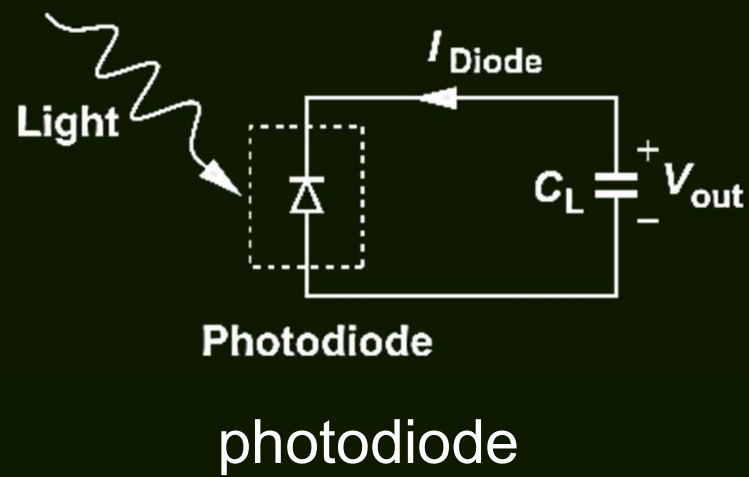A low-noise amplifier is needed for signal boosting without excessive noise.
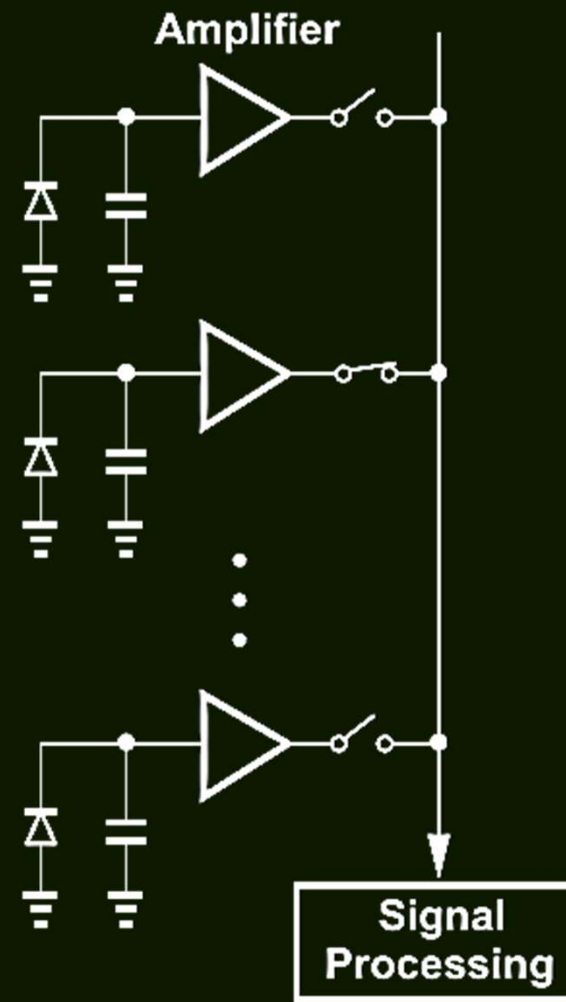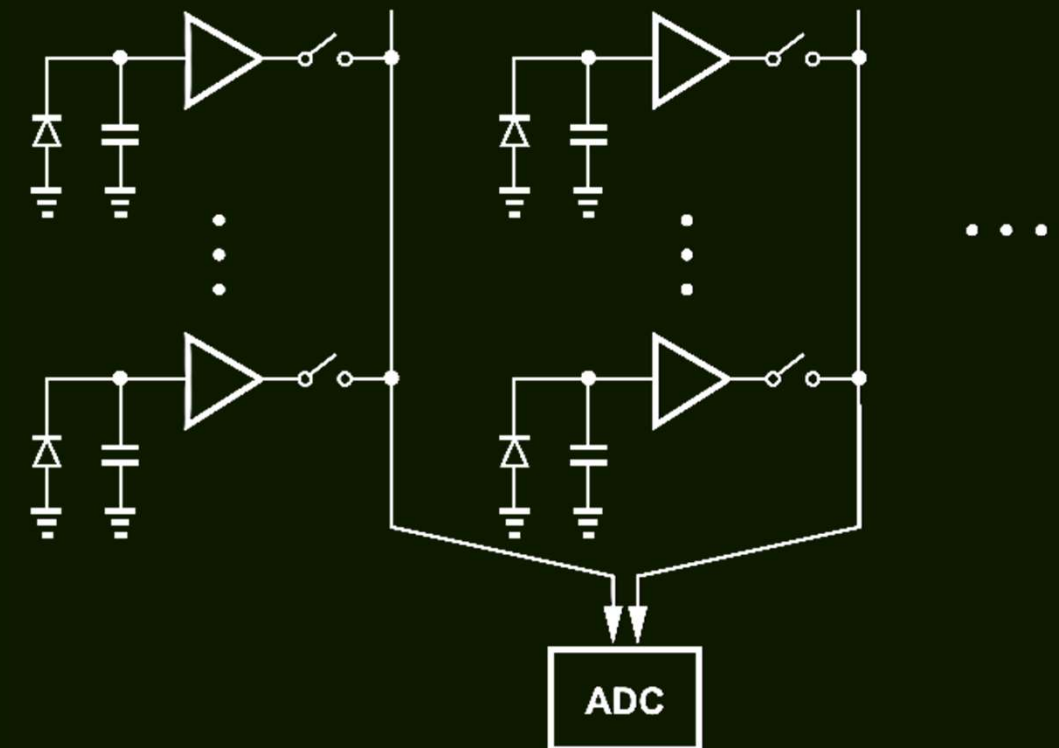
wireless communication system

array of pixels in a digital camera

Sharing one ADC between two columns of a pixel array

photodiode

one column of the array

15

TRANSDUCERS
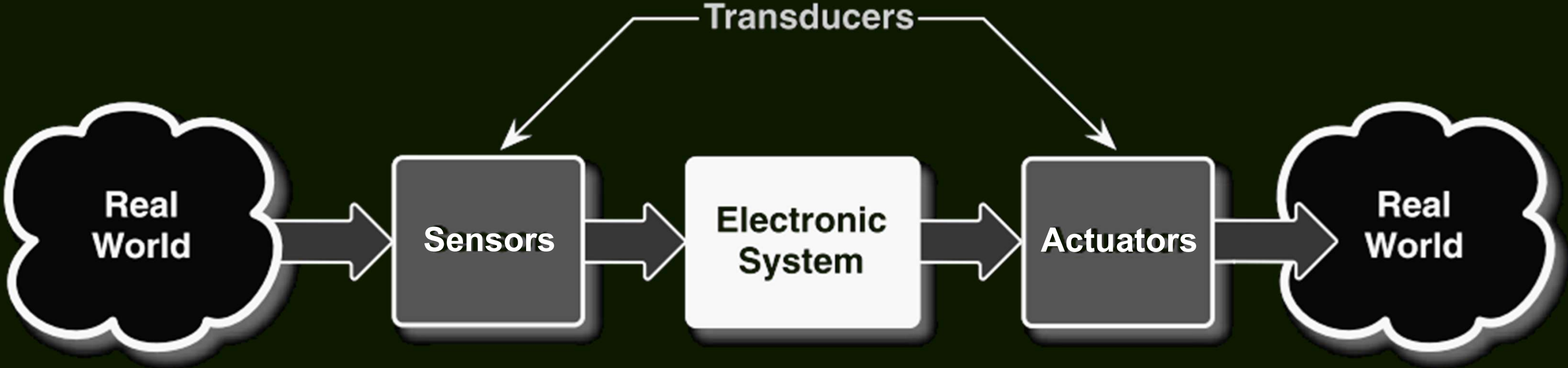
Entire system involving real-world signals

Art of Electronics: Analysis vs. Design

System/circuit → **Analysis** → Specifications or properties

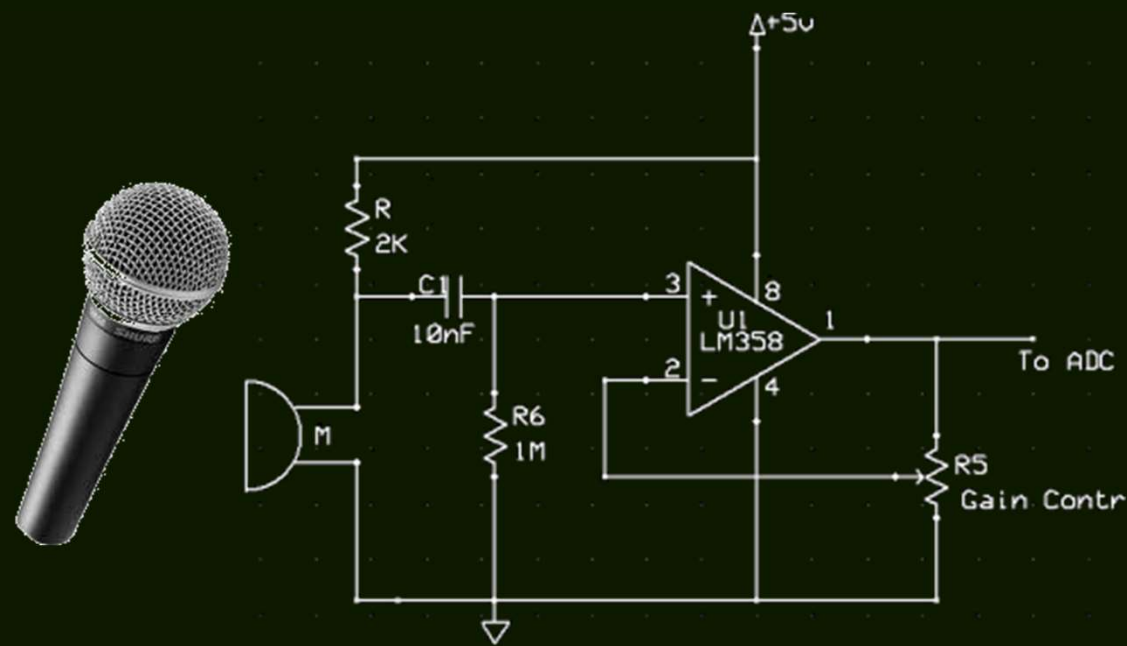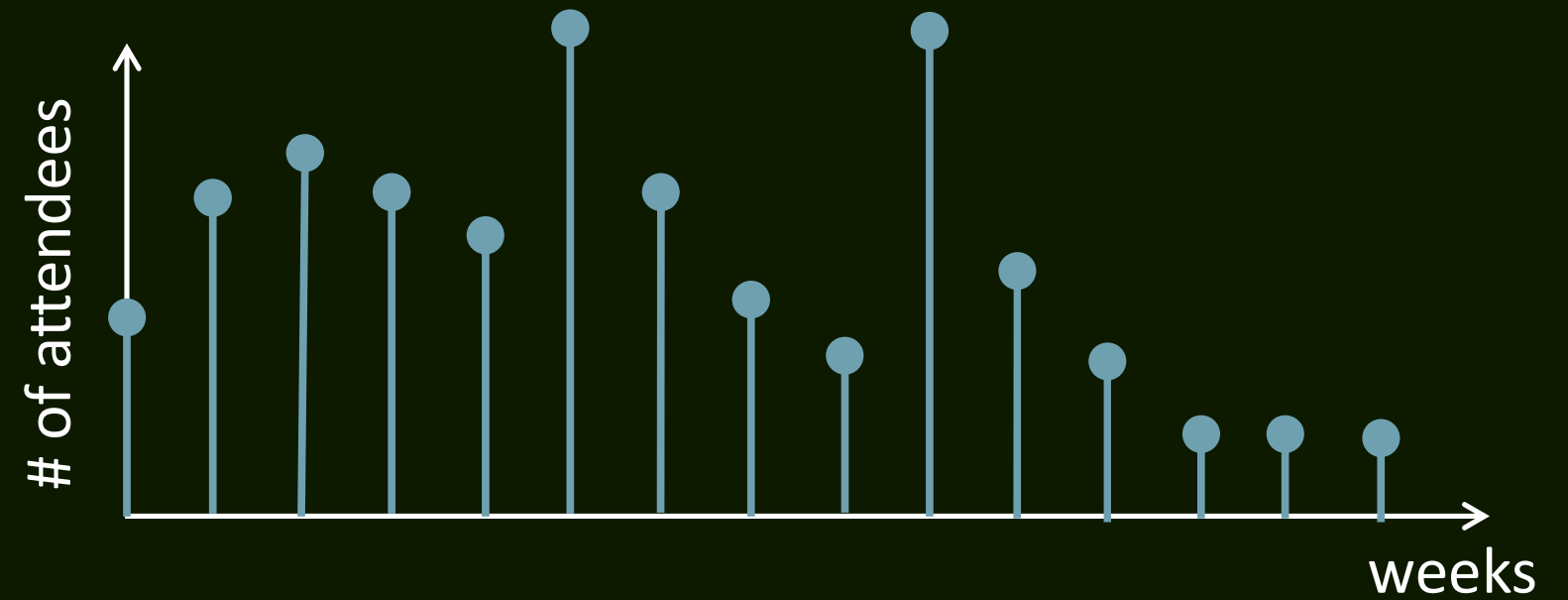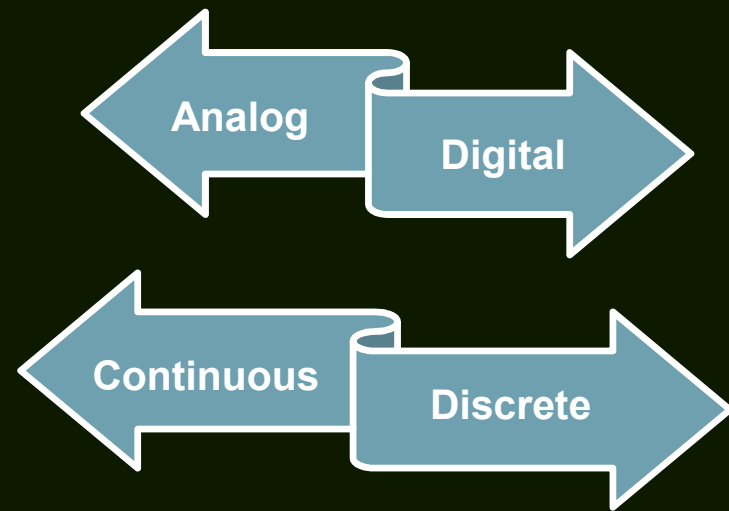Specifications or properties → **Design** → System/circuit, System/circuit, System/circuit

Signals

Signal : it is more general than *current* or *voltage*

$f(\cdot)$ Any sequence of numbers

Analog

Digital

Continuous

Discrete
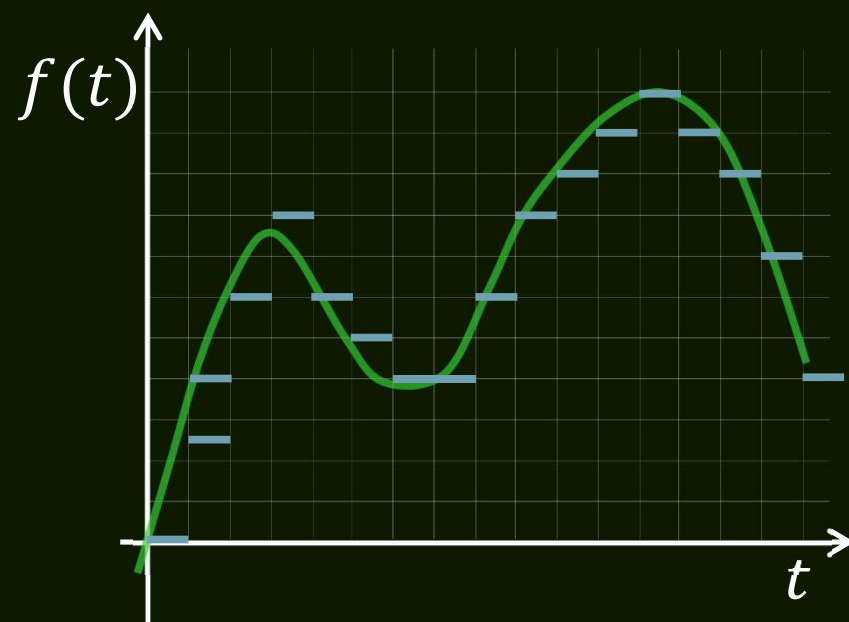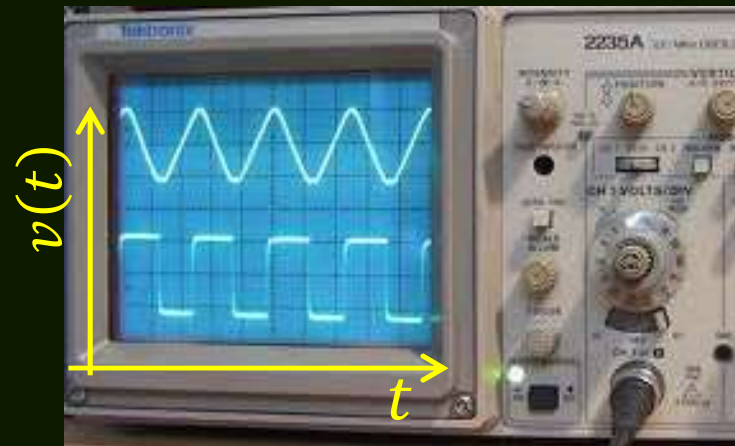
\# of attendees

weeks

?

Mp3 file?

Signals

Signal : it is more general than *current* or *voltage* $f(\cdot)$

oscilloscope

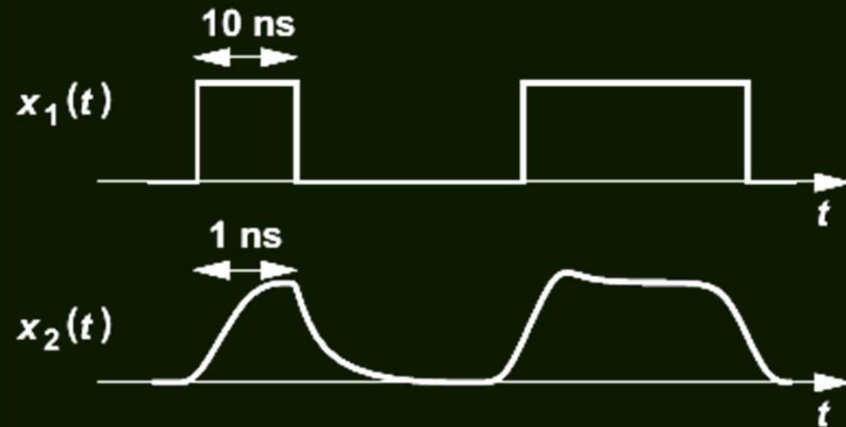analog signal / continuous signal
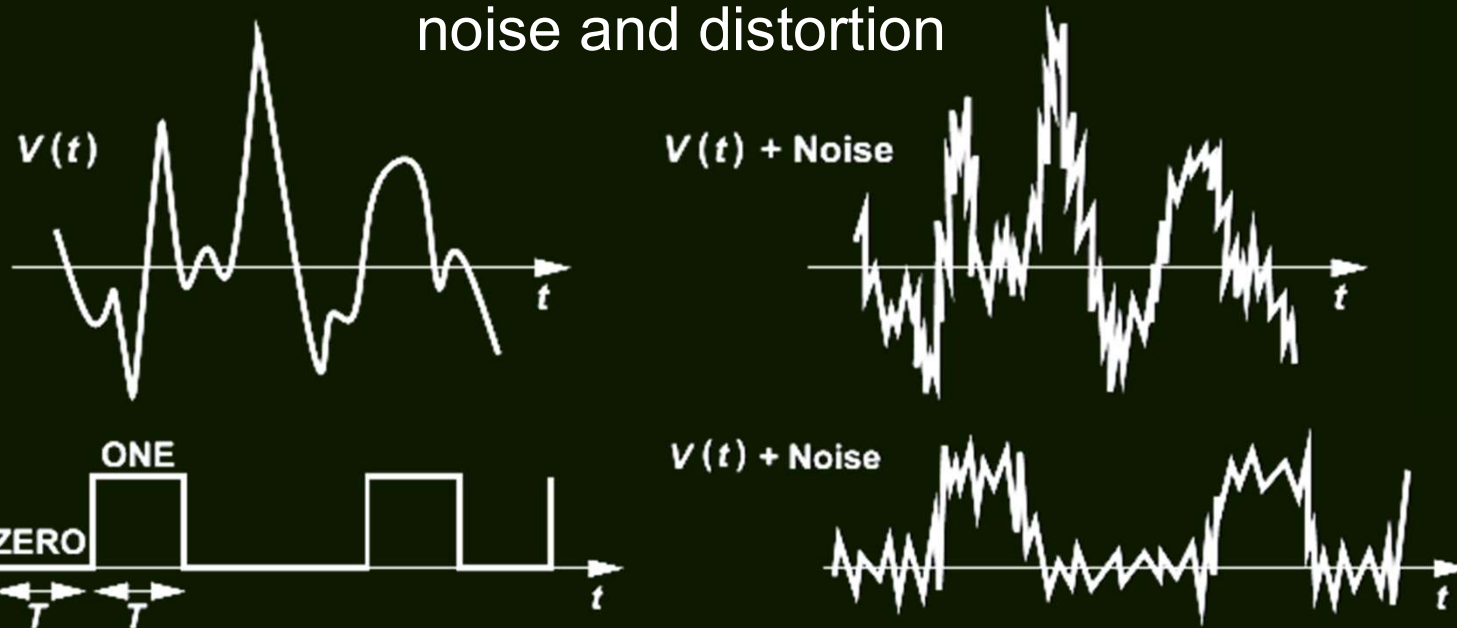digital signal / discrete signal

Analog vs. Digital
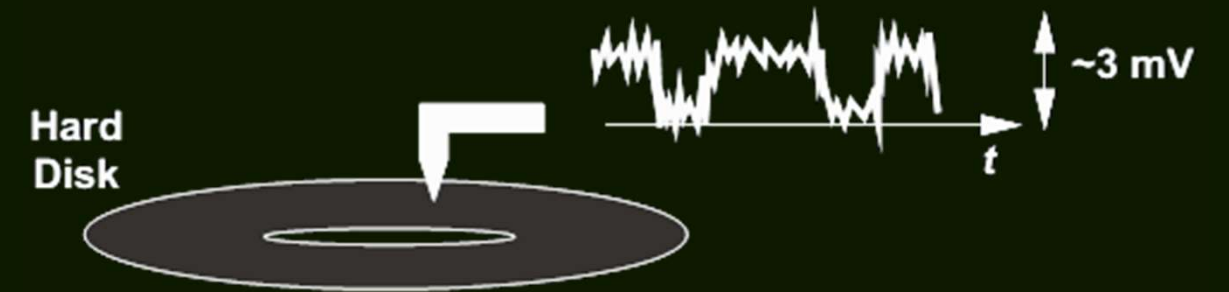
Data waveforms at

100 Mb/s and
1 Gb/s

10 ns

$x_1(t)$

1 ns

$x_2(t)$

noise and distortion

$V(t)$

$V(t)$ + Noise

$V(t)$

ONE

ZERO

T T

$V(t)$ + Noise

digital signals more "robust"

Analog Signal → Analog Processing → Analog–to–Digital Conversion → Digital Processing and Storage

Signal processing in a typical system

Hard Disk

~3 mV

Signal picked up from a hard disk in a computer

end