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TECH 101

ELECTRONIC MUSIC RESEARCH CENTERS

TO RECORD OR TO SYNTHESIZE

Music Concrete	Elektronische Musik
France	Germany
Recorded Sounds	Synthesized Sounds
Montage, Film	Art Music, Serialism
Pierre Schaeffer	Herbert Einmert

Columbia-Princeton Electronic Music Center (1958)

Piece for Tape Recorder (1956)

Vladimir Ussachevsky

I believe that the virtually unlimited source of sounds available to a composer who works with tape requires perhaps as great vigilance in selecting the proper material as would normally be exercised in determining an orchestral palette, if not greater. It is tempting to parade unusual sounds; and the structural unity of a composition can be seriously weakened by diverting attention with an overabundance of such sounds. To avoid creating these distractions in *A Piece for Tape Recorder,* I restricted my raw material to the following:

Non-electronic: a gong, a piano, a single stroke on a cymbal, a single note on a kettledrum, the noise of a jet plane, a few chords on an organ.

Electronic: four pure tones, produced on an oscillator, a tremolo produced by the stabilized reverberation of a click from a switch on a tape recorder.

202

From Ussachevsky's Notes on *Piece for Tape Recorder*

BBC Radiophonic Workshop (1958)

Daphne Oram, Brian Hodgson, Delia Derbyshire, David Cain, and many more...

LOOK AT ORAMICS (1961)

Daphne Oram

Drawing Sounds

Developed “Oramics” in 1959, a graphically controlled synthesizer.

Classically trained musician and BBC engineer.

Visited Schaeffer and RTF in Paris


Press
BBC NEWS
11:48
T REWARD SHOULD BE LINKED TO SUCCESS, NOT

Daphne Oram

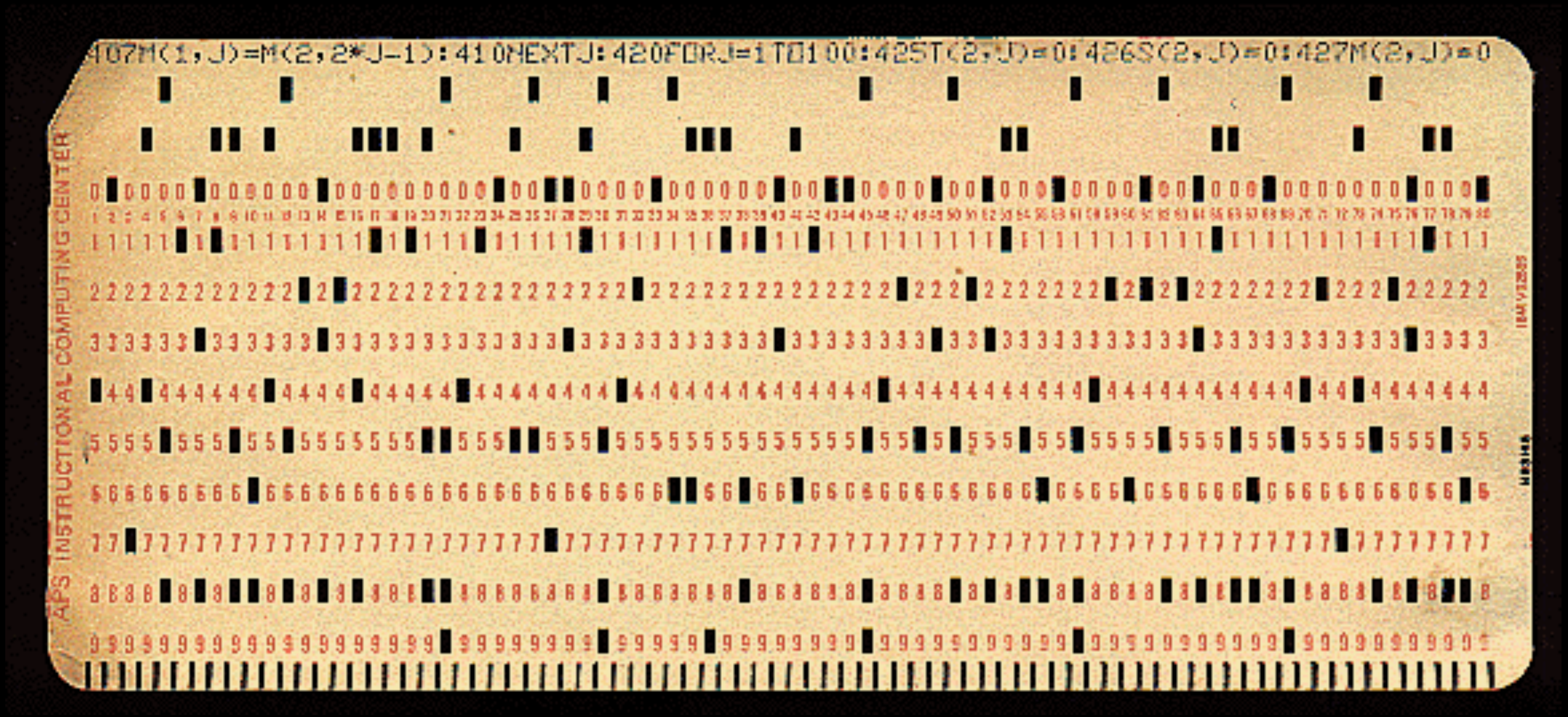
OTHER IMPORTANT ELECTRONIC MUSIC CENTERS

Studio di Fonologia Musicale, Italy (1953)

Luciano Berio & Luigi Nono

Nippon Koso Kyokai (NHK) Japanese Broadcasting Corporation (1954)

Toshiro Mayuzumi & Toru Takemitsu

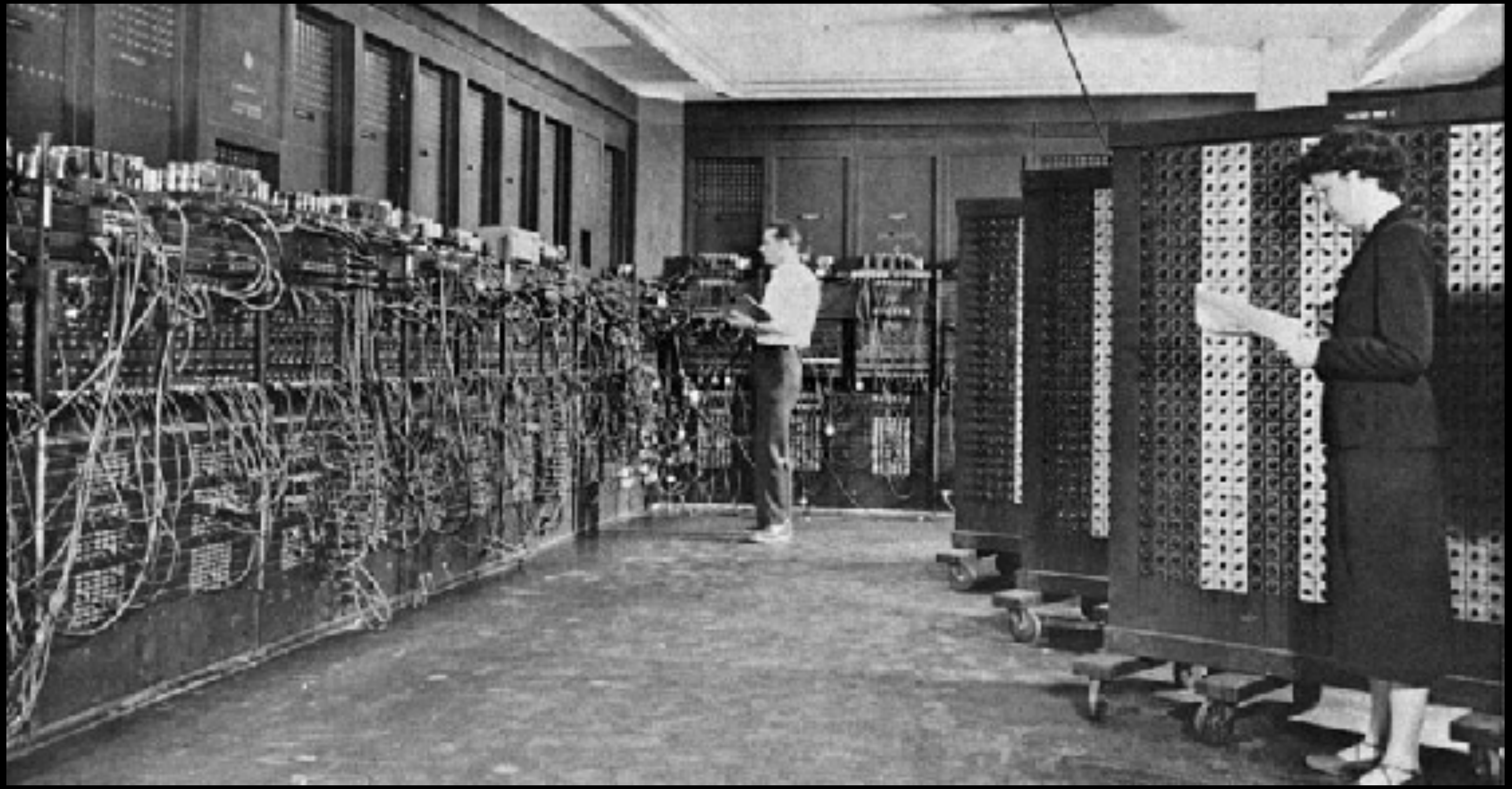


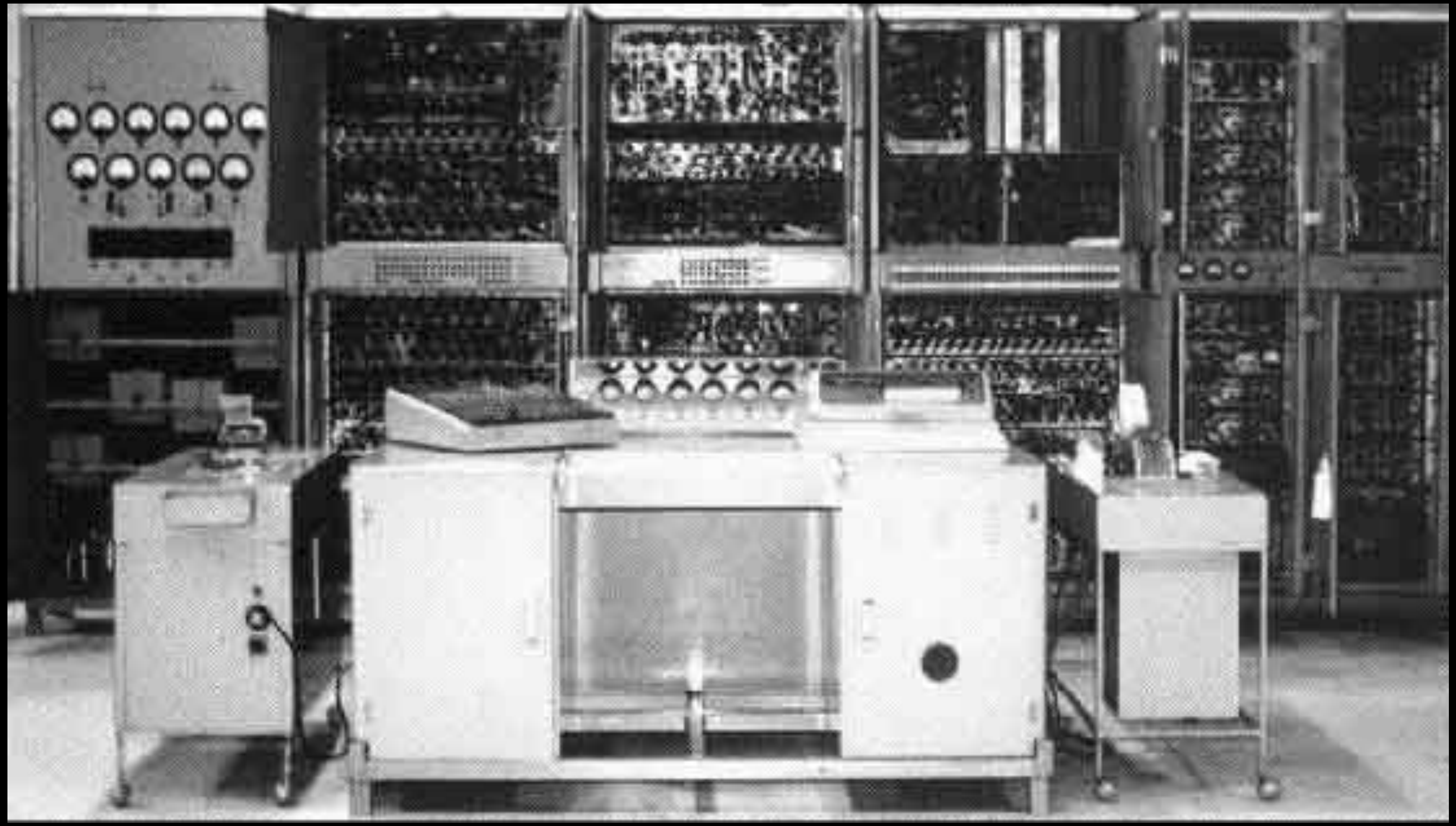
DIGITAL AUDIO & COMPUTER MUSIC

Patchwork (1977)
Laurie Spiegel

brief history of early computer audio

basics of digital audio





BEFORE 1957

1928: Harold Nyquist at Bell Labs develops Nyquist Theorem

1938: pulse code modulation (pcm) technique developed

1946: ENIAC, first general purpose computer

195?: Digitally synthesized sounds

in the earliest computers, sound was used to signify operation

BELL LABS & MAX MATHEWS

At Bell Labs in 1957, Mathews created the first sound generating computer program, called... *Music*

MAX MATHEWS

Often cited as the "Father of Computer Music"

He continued to develop *Music (the program)* throughout the 1960s

first real-time computer system *Groove* in 1968

a conductor program and instrument called the Radio Baton

From 1987 to 2011, Professor of Research at Stanford University.

The program *Max/MSP* is named in his honor


crown

What now is the musical challenge of the future? I believe it is the limits in our understanding of the human brain; and specifically knowing what sound waves, sound patterns, timbres and sequences humans recognize as beautiful and meaningful music – and why!

Max Mathews

In 1961, Mathews arranged and recorded “Daisy Bell” for computer synthesized voice.

Stanley Kubrick was researching what a telephone would look like for his 1968 film, *2001 Space Odyssey* and heard Mathew’s version of the well-known tune and referenced it in the climatic scene.

In 1961, the IBM 7094
became the first
computer to sing,
singing this song.
Vocals were programmed
by John Kelly and
Carol Lockbaum and the
accompaniment was
programmed by Max
Mathe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Computer Music in the 60s & 70s

Large mainframe computers at institutions, shared by multiple departments

Sloooooooowwwwwwwww

Composers who worked at Bell Labs with Max Mathews in the 60s and 70s included: James Tenney, F. B. Moore, Jean Claude Risset, John Chowning, Laurie Spiegel and Charles Dodge

Basics of Digital Audio

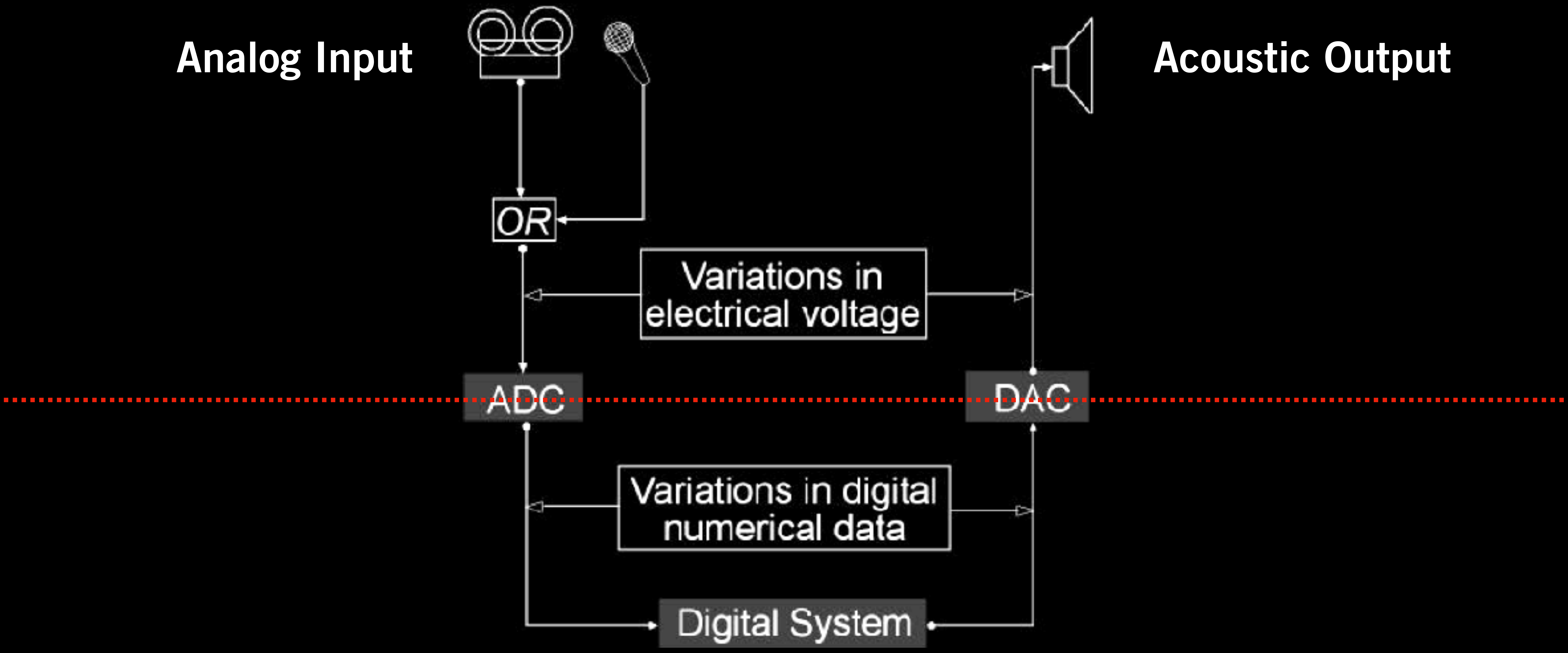
Encoding - Analog to Digital Convertor (ADC) takes “snapshots” of electrical signals

Decoding - Digital to Analog Convertor (DAC) converts numbers into continuous electrical signals.

Quantization - The process of taking an analog signal and converting it into a finite series of discrete levels.

Levels stored as numbers stored as bits (binary).

Big Picture Signal Flow



DIGITAL ENCODING

Digital is discrete, Analog is continuous

Sampling Rate and **Bit Depth** work together to determine the resolution and accuracy of the digital representation

Two Parameters of Digital Encoding

Pulse-code modulation (PCM)

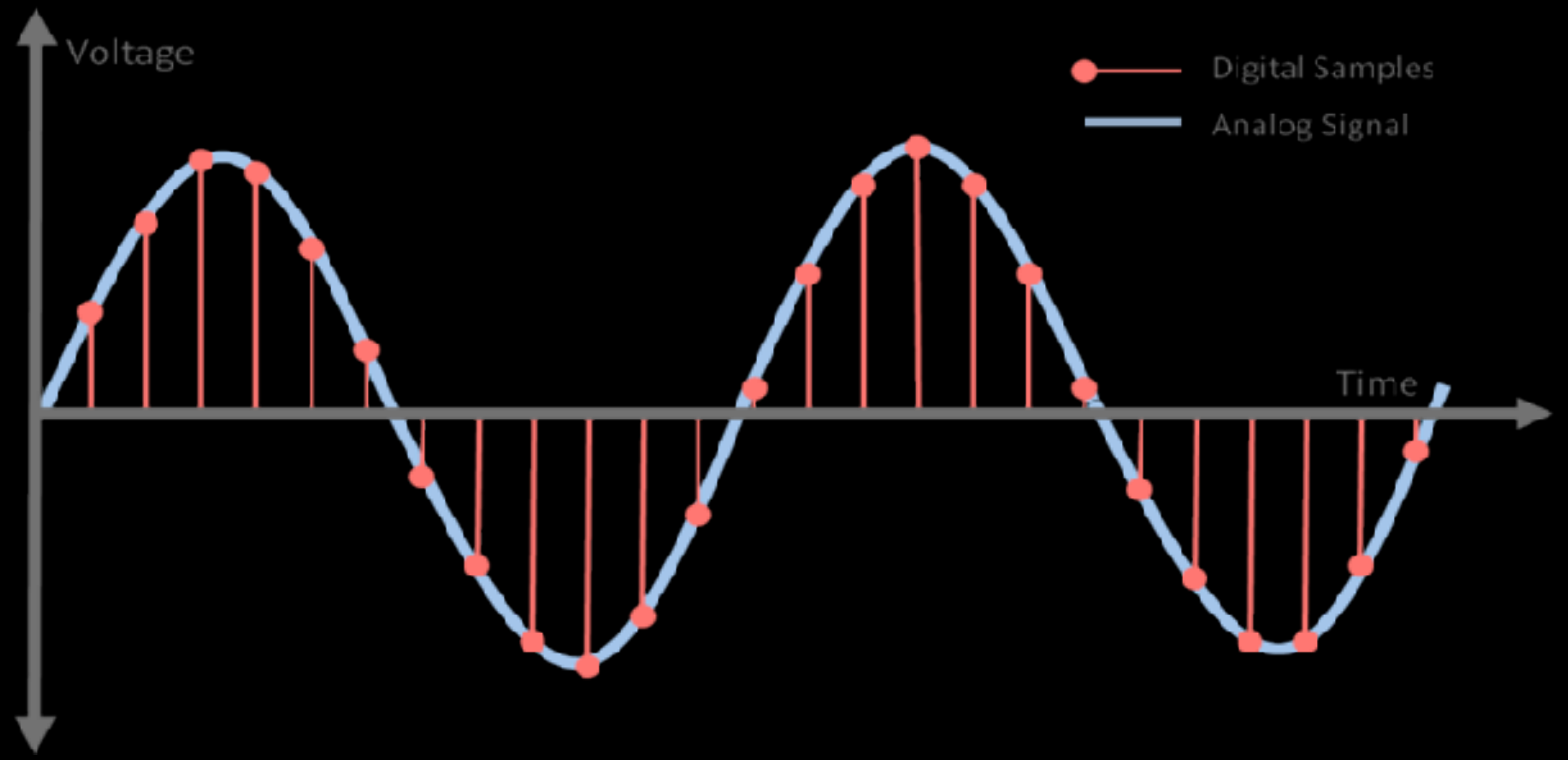
Sampling Rate

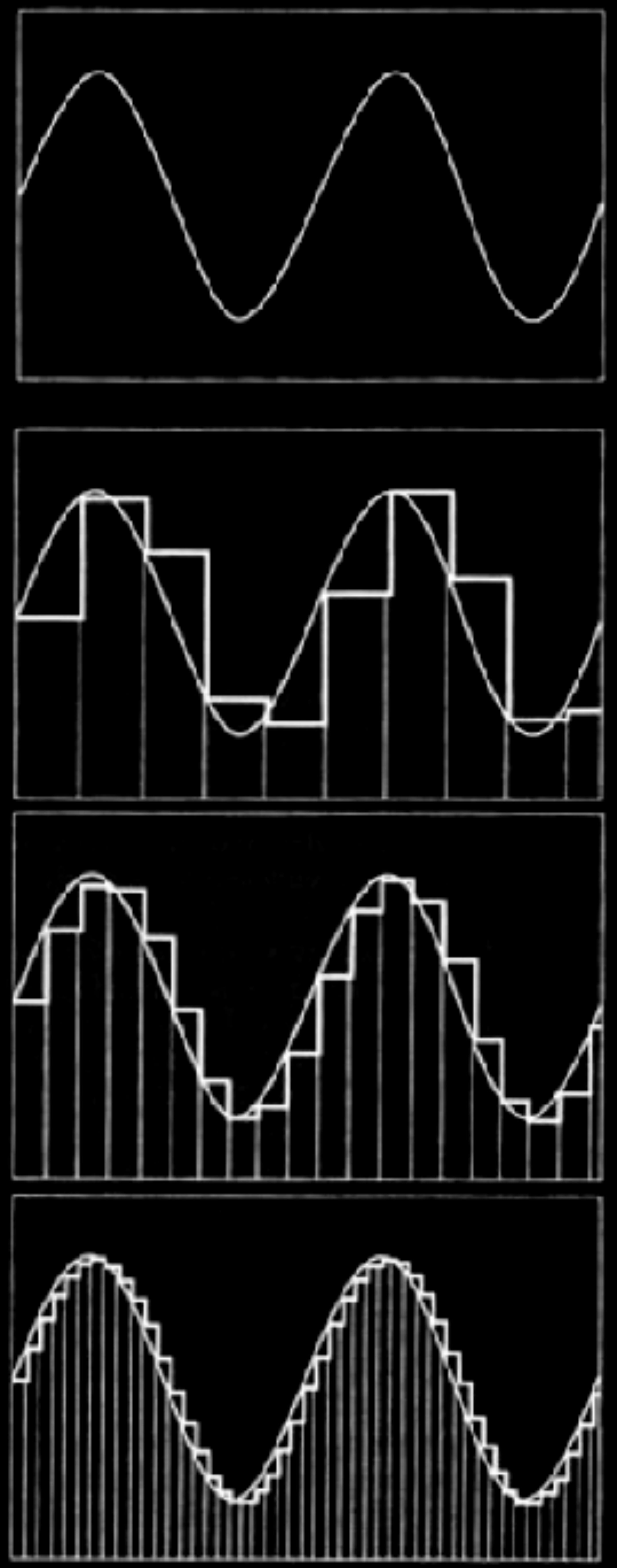
How quickly are the amplitudes of a signal measured? (time interval)

Bit Depth

How accurate are amplitude measurements when sampled? (pressure resolution)

Sample Rate - Film Analogy*





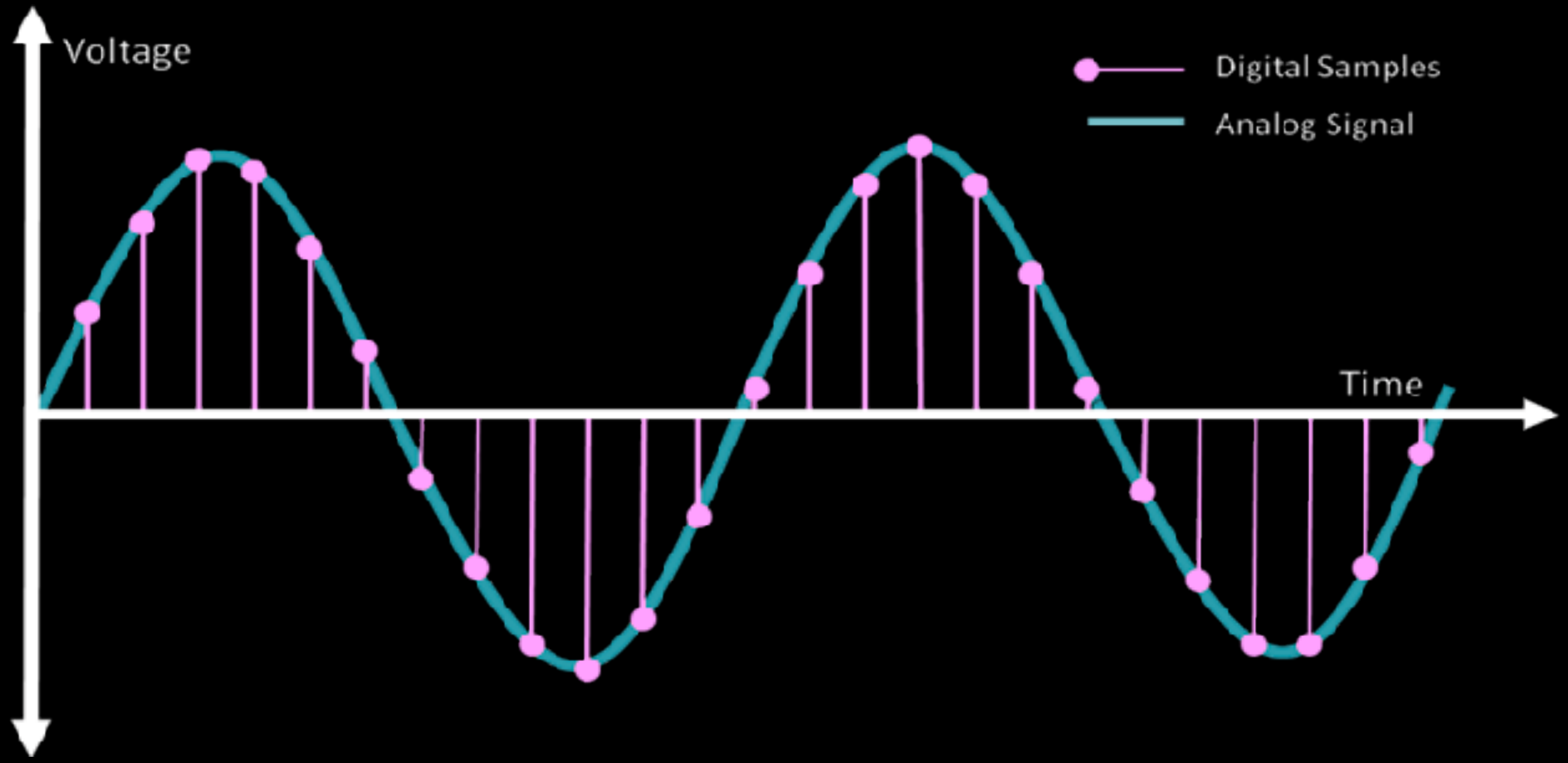
Sampling Rate

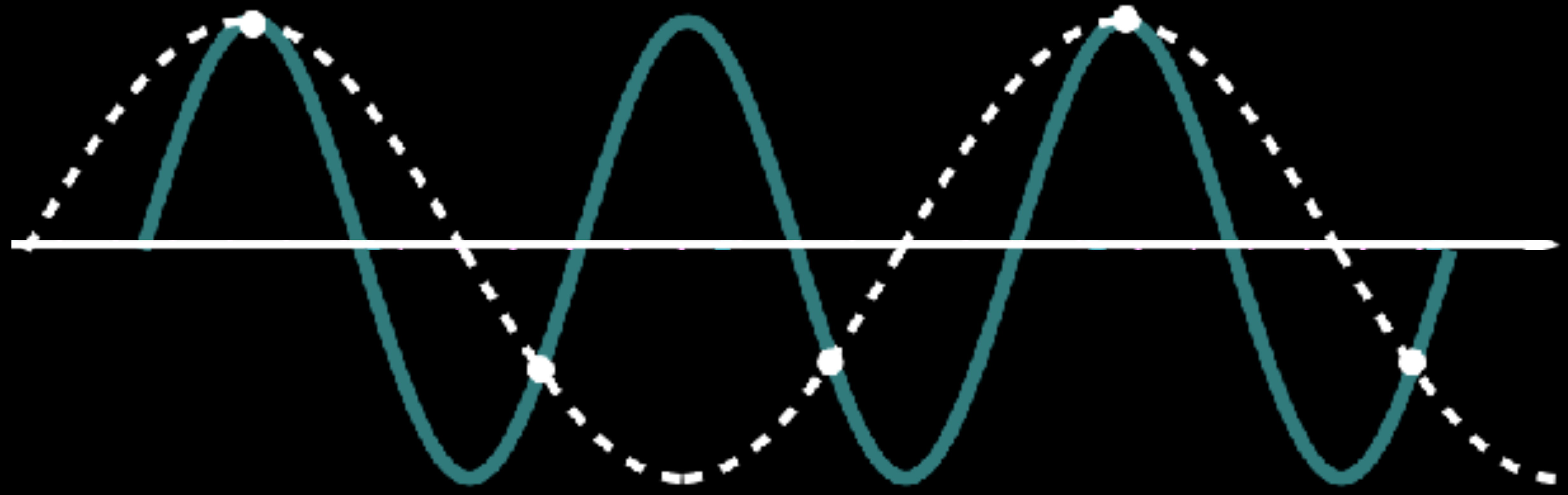
measured in hertz (Hz)

the faster we sample, the better chance we have of getting an accurate picture of the signal

in order to represent all sounds within the range of human hearing we require a sampling rate of (at least) (Nyquist Theorem)

Unwanted artifacts are audible when the sampling rate drops below 2x the highest frequency. (Aliasing)





Nyquist Theorem

to accurately represent a signal, the sampling rate must be at least twice the highest frequency contained in the signal.

In mathematical terms:

$$f_s \geq 2f_c$$

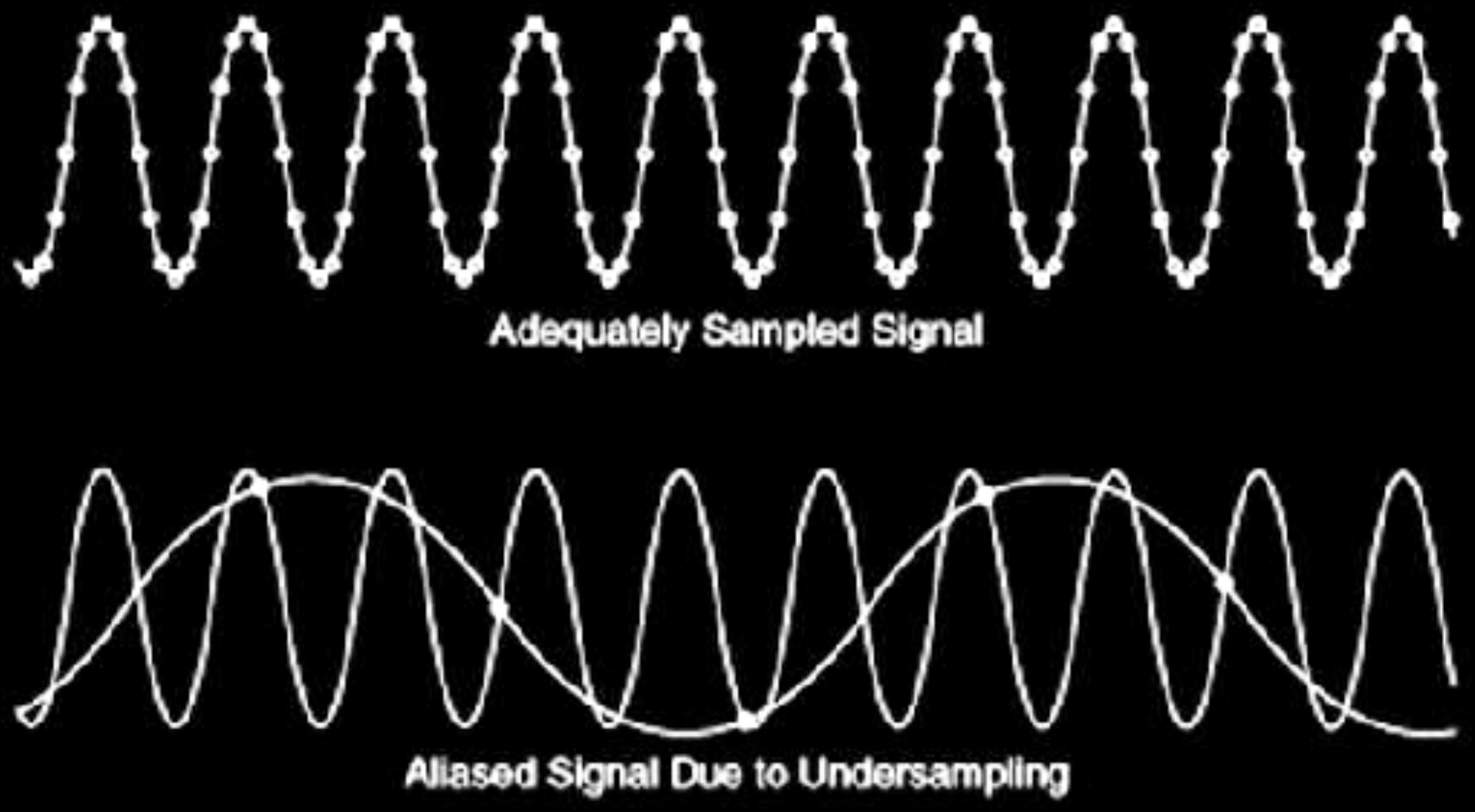
where f_s is the sampling rate and f_c is the highest frequency contained in the signal

Aliasing

a result of undersampling

you not only lose information about the signal, but you get the wrong information.

the signal takes on a different “persona” -- a false presentation or “alias”



Review: Class I

Defining electronic music: *techniques* + technology + concepts

"Purely Electronic Music"/ Synthesized Music / ("Elektronische Musik")

- Analog vs. Digital

"Electroacoustic Music" / ("Musique Concrète")

- Live vs. Fixed ("acousmatic")

Review: Class II

Acoustics vs. Psychoacoustics (Objective vs. Subjective)

Waves

- Propogation through a medium (displacement rather than transfer)
- Periodic vs. Aperiodic

Amplitude vs. Loudness, Decibels (dB)

- Inverse Square Law (double distance -> quarter intensity)
    - $\text{intensity} = 1 / \text{distance}^2$

Frequency vs. Pitch, Hertz (Hz)

- frequency = 1 / period (of wave length)

Review: Class III

Sound & Space

- Direct Sound vs. Reflected, Absorbed, and Diffused Sound

Microphones

- Polar Pattern: angular sensitivity (cardioid, omni, figure 8, etc.)
- Transduction Principle: acoustic->electric (dynamic, condenser, ribbon)

Review: Class IV

Magnetic Tape - records signals as polarity differences in iron oxide dust

Manipulation Procedures

Speed shift, reverse, cutting, splicing, looping, mixing

Review: Class V

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