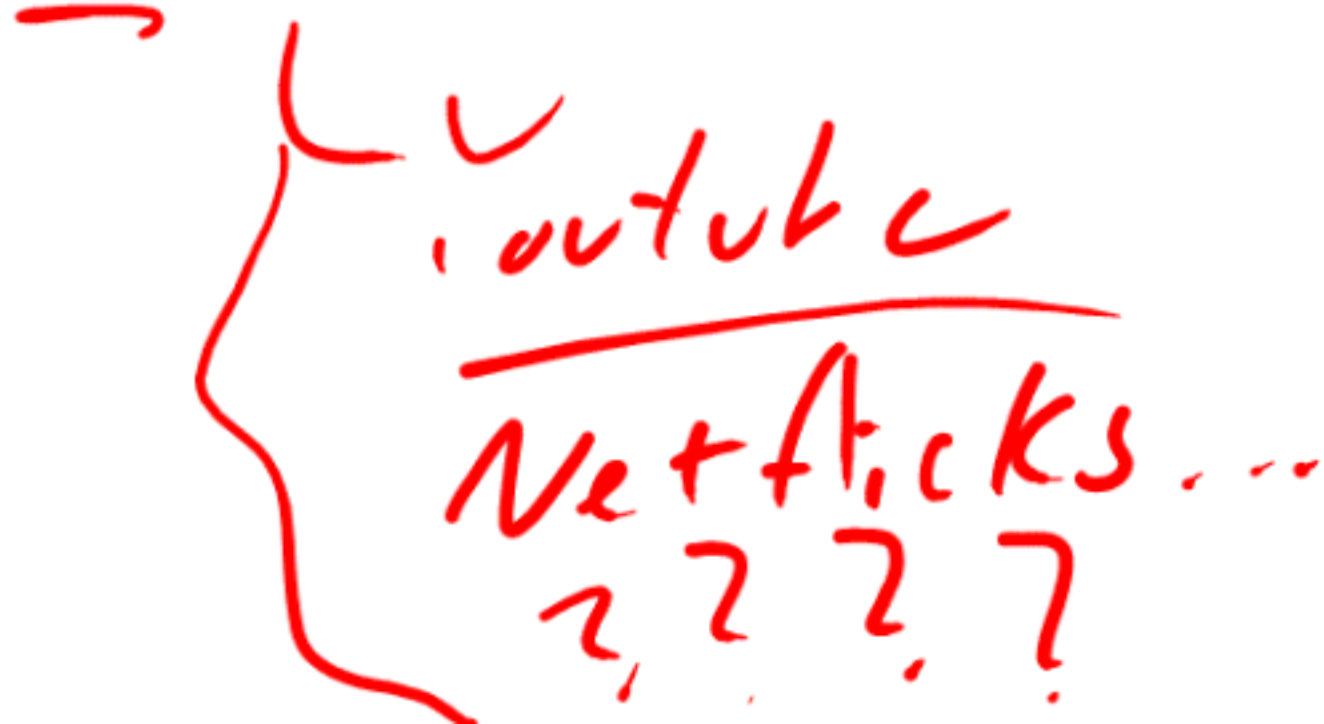
SE3910 – REAL TIME SYSTEMS

Audio and Video Constraints



ROADMAP

- Today
  - An Introduction to audio/video
- Friday (Tentative)
  - Real Time Coding Standards -

OBJECTIVES

- Explain the relationship between bandwidth and image quality for a video stream.
- Calculate the bandwidth needed to deliver a given quality image
- Explain the stroboscopic effect
- Calculate the maximum data rate of a channel under both noiseless and noisy signal conditions
- Explain the Nyquist theorem related to sampling
- Calculate the minimum sampling rate necessary to transmit a signal using the Nyquist Theorem
- Explain the relationship between the number of bits and quality when sampling a signal

- How is an image stored in memory?

⇒ Depends on file

"Bitmapped format"

Each pixel is in memory

2D Array of pixels

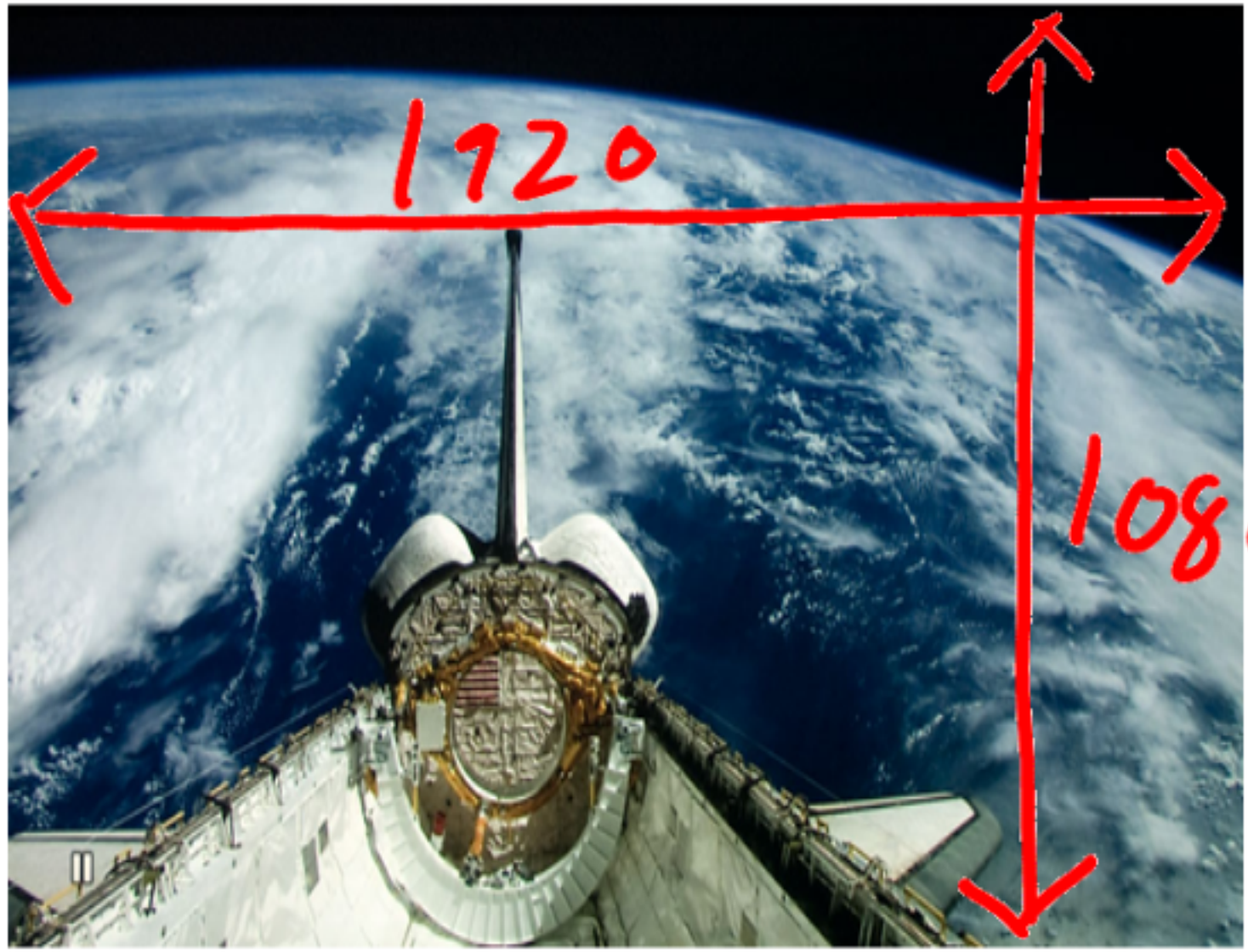
Grayscale ⇒ Each pixel has 1 byte

100 x 100 ⇒ 10000 pixels

≈ 10 KB

WHAT DOES 1080P MEAN?

- 1080p: The modern Television Standard



60 frames per second are transmitted.

HOW BIG IS A 1080P IMAGE?

- Calculation: Width x Height X bytes per pixel

1920 x 1080 24 ~~bits~~ bits per pixel

X 3

6220800 bytes/image

6220 KB

6.22 MB

- Bandwidth = Size of one frame x frame ~~size~~ rate

HOW MUCH DATA IS TRANSMITTED PER SECOND? (UNCOMPRESSED)

6.22 MB x 60 frames/second

From 1 1

6.22

⇒ B

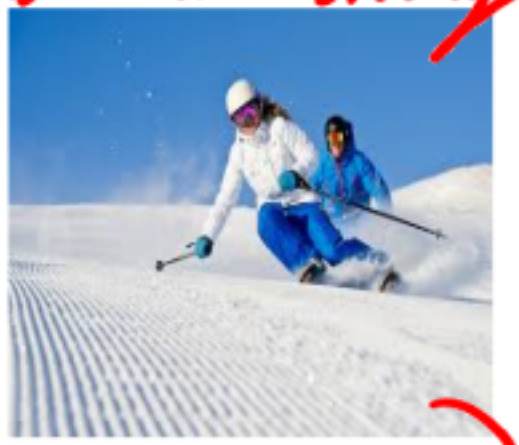
60

373.20 MB/second 37320

HOW FAST DO WE NEED AN IMAGE TO SHOW?

- Depends on how much motion we have in the picture...

Downhill sking



FAST

Fast frame Rate

Curling

Slow

Slow frame Rate

Steamboat Willie 12 fps

Movie Theater 24fps

60-100 fps

THE STROBOSCOPIC EFFECT

- Have you ever noticed something that is in motion seem to stop?

Car wheel

Water drop ...

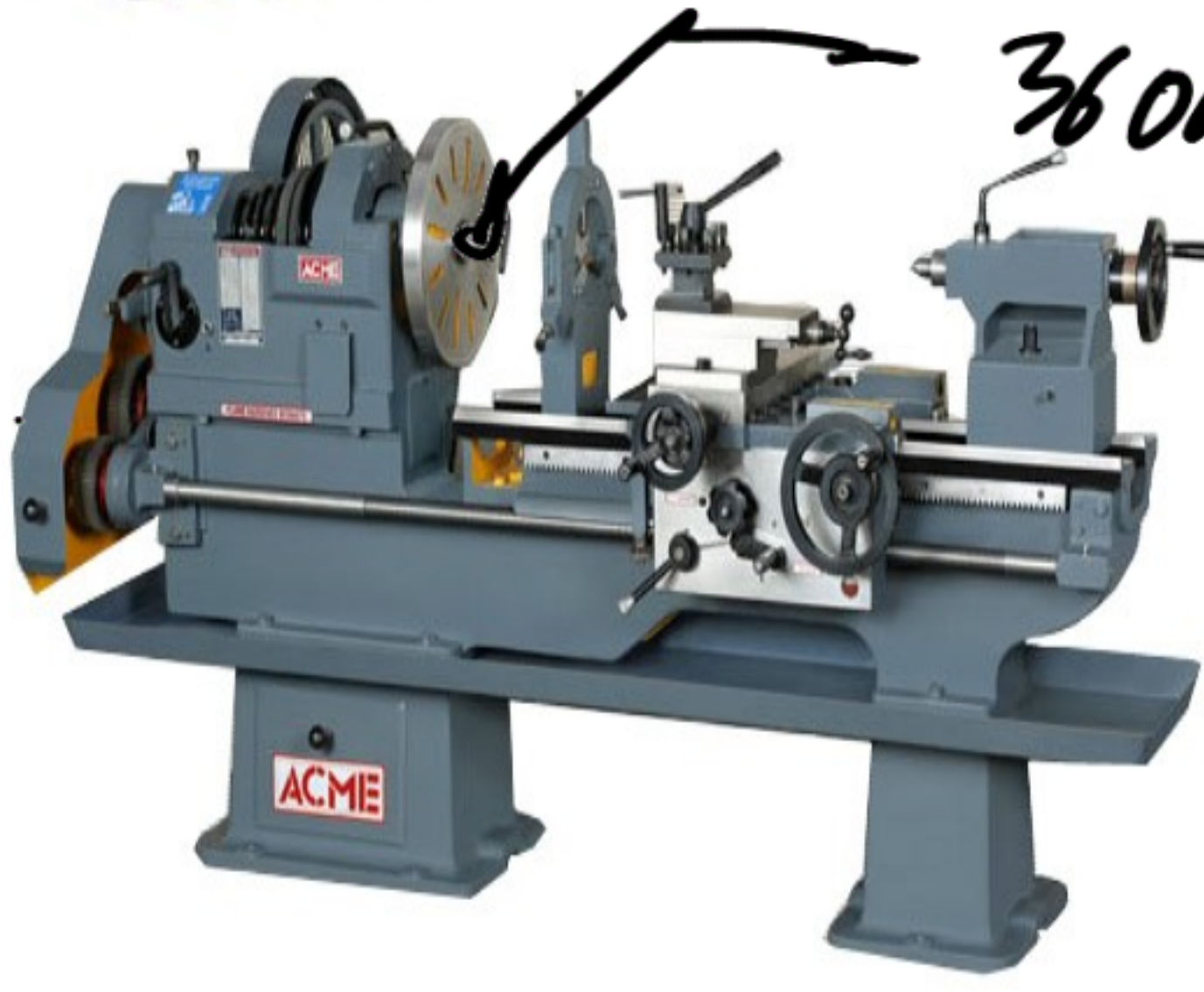
SOME EXAMPLE VIDEOS SHOWING STROBOSCOPIC EFFECT

- http://upload.wikimedia.org/wikipedia/commons/thumb/7/77/Propeller_strobe.ogv/220px--Propeller_strobe.ogv.jpg

- http://upload.wikimedia.org/wikipedia/commons/thumb/e/ef/The_wagon-wheel_effect.ogv/220px--The_wagon-wheel_effect.ogv.jpg

A SAFETY MOMENT

120 times a second



3600 RPM...

SE3910 REAL TIME SYSTEMS

This im aq

TRANSMITTING DATA

- Physical Layer
  - You didn't talk too much about this in Network Protocols
  - Can occur through many mediums
    - Twisted Pair
    - Coaxial Cable
    - Fiber Optics
    - Wireless

WHAT IS THE MAXIMUM RATE OF A CHANNEL?

- Henry Nyquist (AT&T Engineer c1924) and Claude Shannon (1948)
- Nyquist Theorem
- $maximum\ data\ rate = 2Hlog_2 V\ \frac{bits}{sec}$

$2 \cdot H \cdot \log_2 2$ bits/s

$2 \cdot H \cdot 1$

Up 30 KHz

Bandwidth of medium 6 KHz

# of levels 5

0,1

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Theoretical Limit

WHAT IS THE MAXIMUM RATE OF A CHANNEL WITH NOISE?

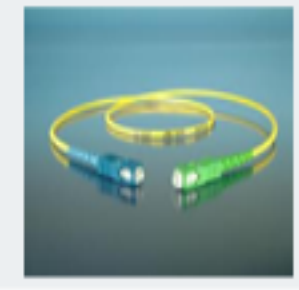
H	SN (db)	Maximum Number of Bits per secon
3000	0	3000
3000	10	10378.29486
3000	20	19974.63445
3000	30	29901.67878
3000	40	39863.56993
3000	50	49828.9647
3000	60	59794.71004
3000	70	69760.49043
3000	80	79726.27432

- Claude Shannon (1948)
- $maximum\ number\ of\ \frac{bits}{second} = Hlog_2\ (1 + \frac{S}{N})$

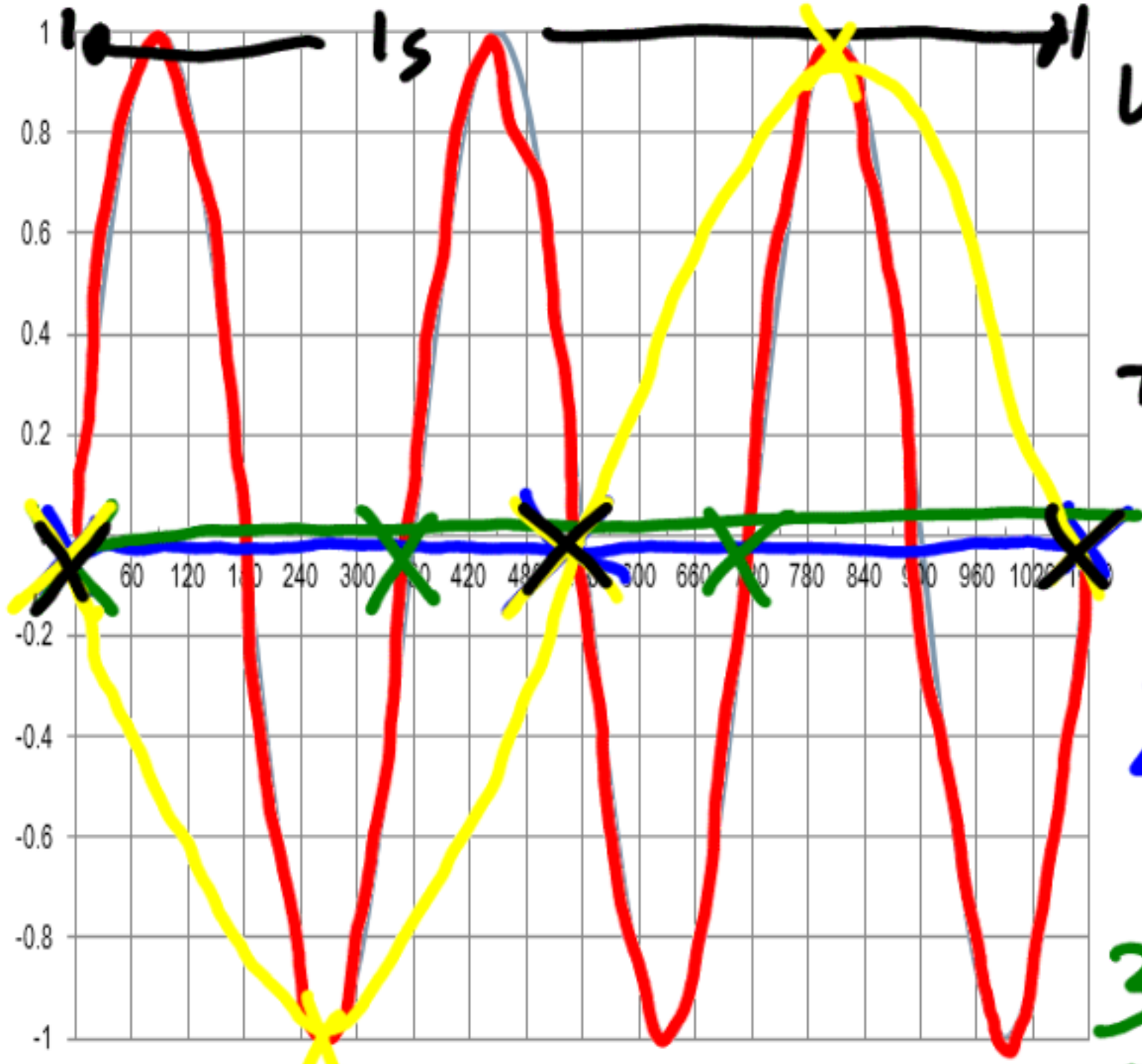
Note: S/N Usually given in DB. To use, must convert using formula 10^DB/10

MAXIMUM BANDWIDTH OF CHANNEL UNDER NOISE

WIRING TYPES

Wiring Type	Bandwidth	
CAT 3 — "phone line"	16MHz	
CAT 5 "ethernet cables"	100 MHz	
Coaxial Cable (50 Ohm) "cable modem"	1-2 GHz	
Fiber Optic	50000 GHz	

SAMPLING THEOREM



what is my frequency?

3Hz

2x per second

3x 1 per second

4x/s

6x/2

SAMPLING THEOREM

- Nyquist Criterion
- => fs > 2B

3k BW => 6k/s

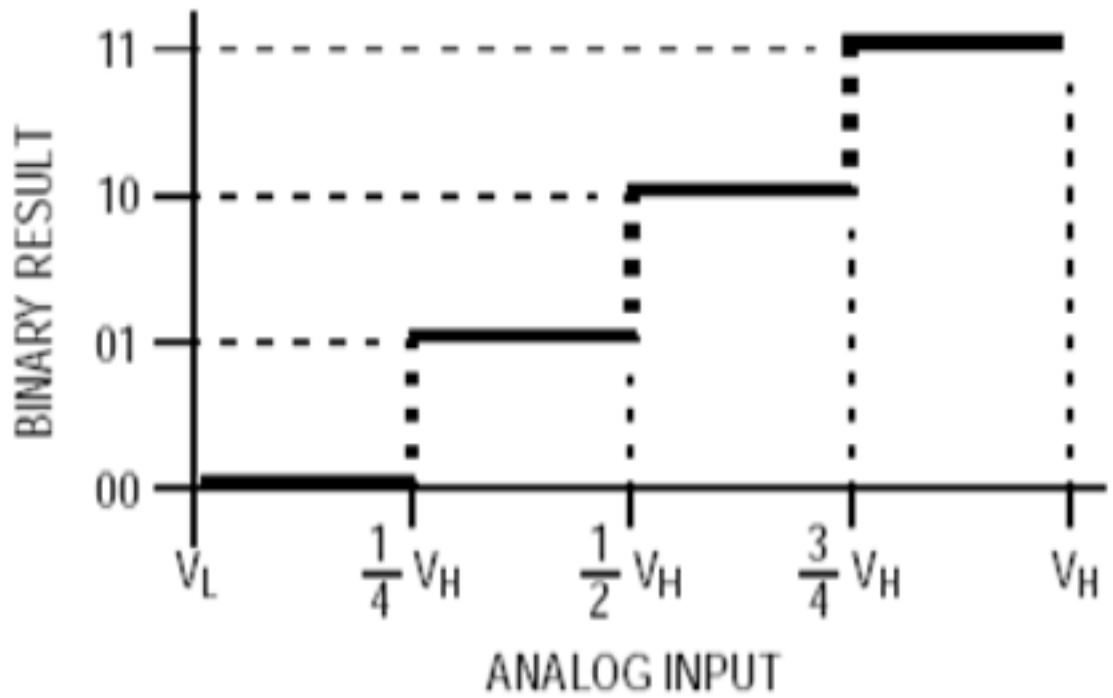
- Nyquist Rate => 2B
- Audio Sampling:

Sample rate	Quality level	Frequency range
11,025 Hz	Poor AM radio (low-end multimedia)	0–5,512 Hz
22,050 Hz	Near FM radio (high-end multimedia)	0–11,025 Hz
32,000 Hz	Better than FM radio (standard broadcast rate)	0–16,000 Hz
44,100 Hz	CD	0–22,050 Hz
48,000 Hz	Standard DVD	0–24,000 Hz
96,000 Hz	High-end DVD	0–48,000 Hz

Telephone 8KHz Telephone 0–3.2kHz

DISCRETIZATION?

- Consider an analog signal that will vary between two values – say 0 and V_H volts
- Discretization refers to the "levels" the ADC is able to resolve the analog signal to:
  - a 2-bit converter can resolve 4 different discrete levels



A/D CO

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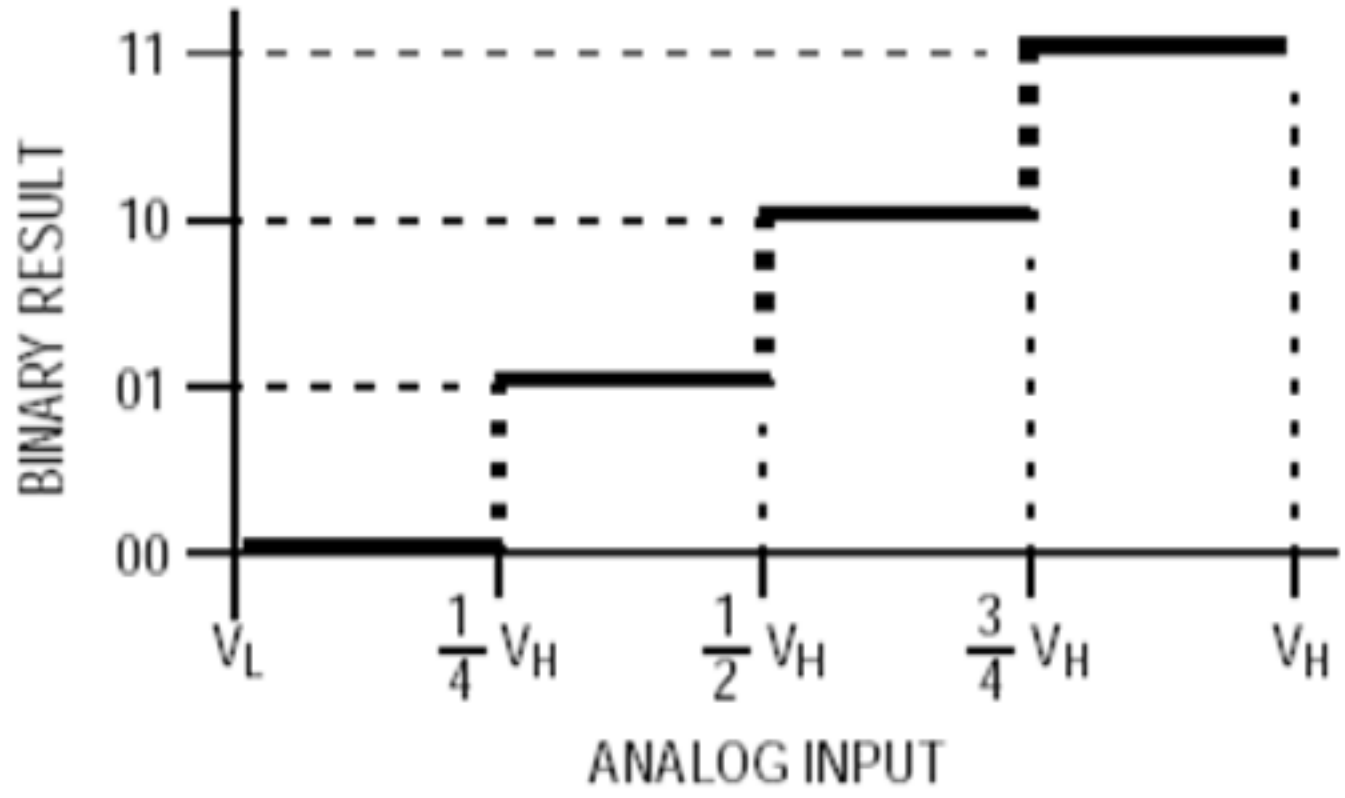
QUANTIZATION ERROR



- Difference between the actual analog value and quantized digital value due is called **quantization error**.
  - Due either to rounding or truncation.

NOISE AND THE NUMBER OF BITS

$$\mathrm{SQNR} = 20 \log_{10}(2^Q) \approx 6.02 \cdot Q \text{ dB}$$