Embedded Software

CS 145/145L

Caio Batista de Melo

- Monday is a holiday!

  - No labs!

- We won't get to have Saehanseul as a guest speaker…

- Please submit the official department evaluations!

  - Completely anonymous, give your honest feedback :)

  - Extra credit on Project 5 demo

  - Make sure to submit evaluations for the instructor (CS145) and your TAs (CS145L)

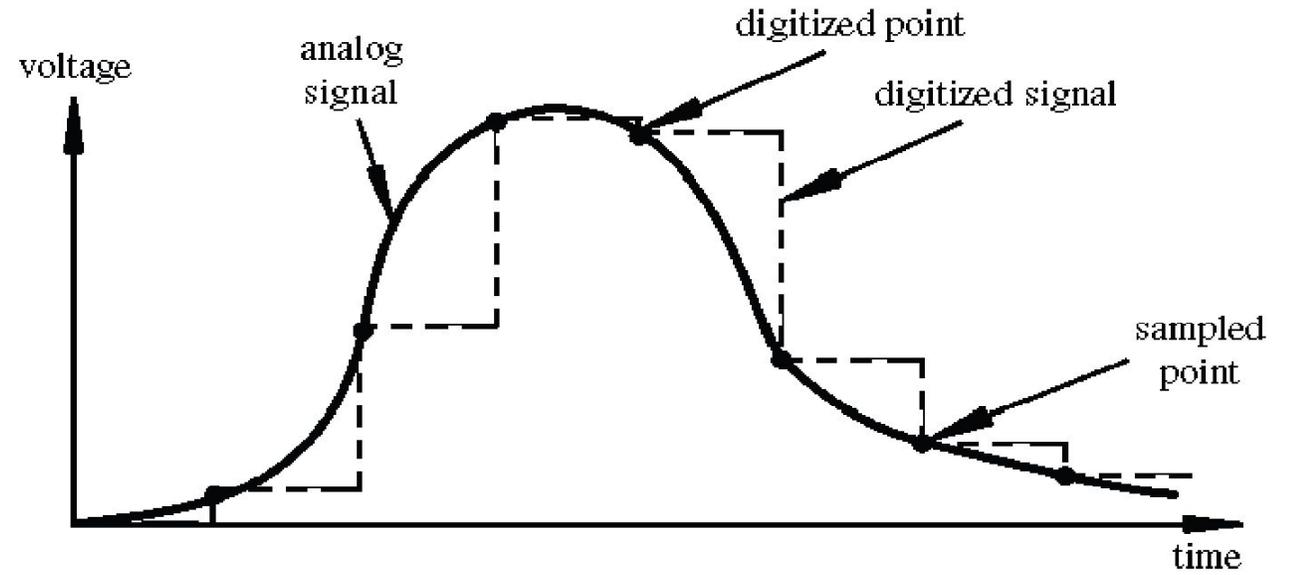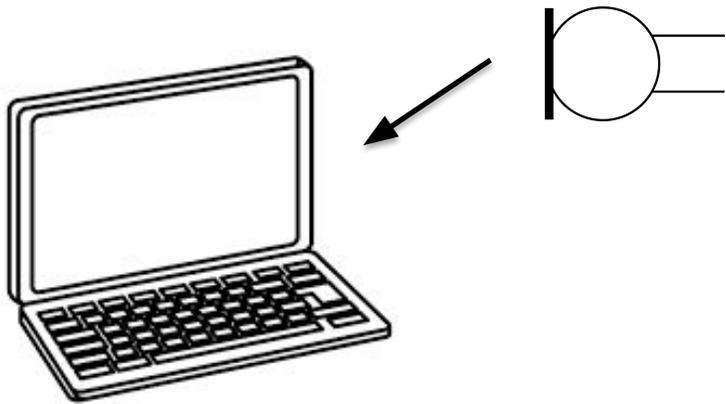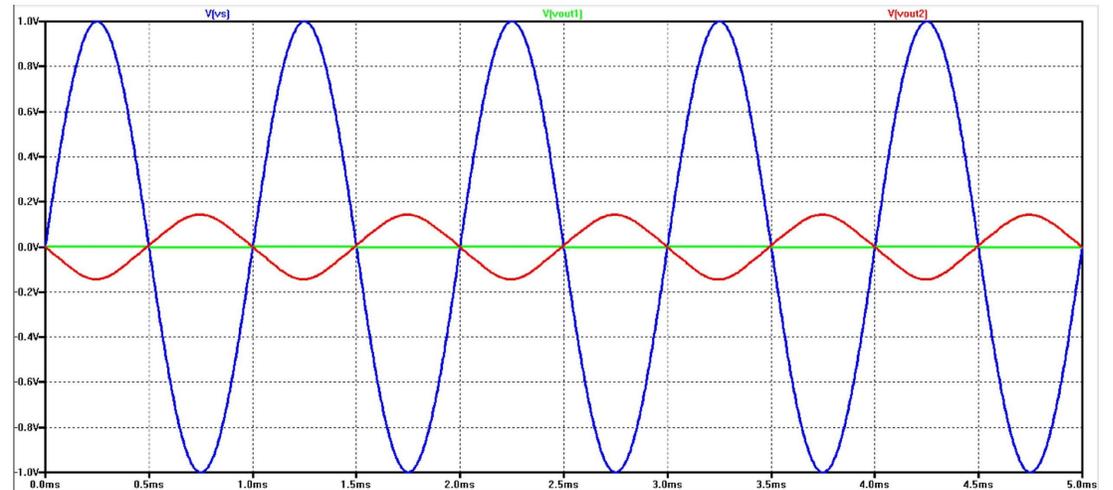 - https://evaluations.eee.uci.edu/

Agenda
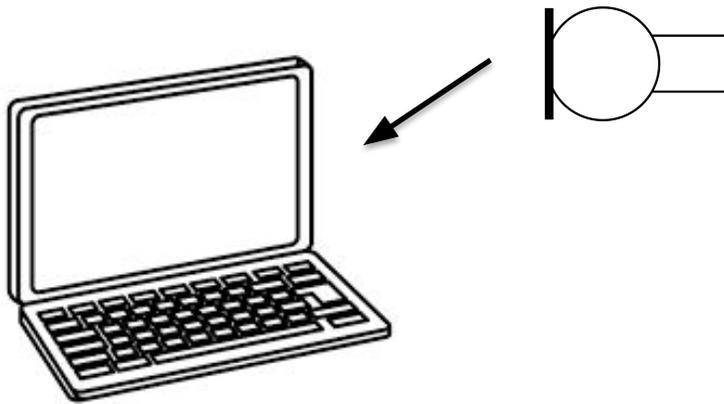
- Recap

- Aliasing

- Low Pass Filters

- Complete Input Pipeline

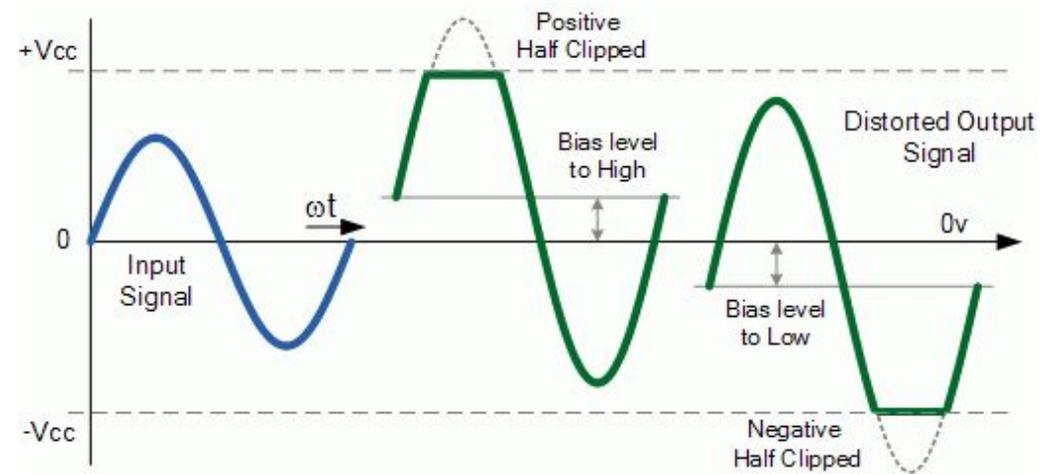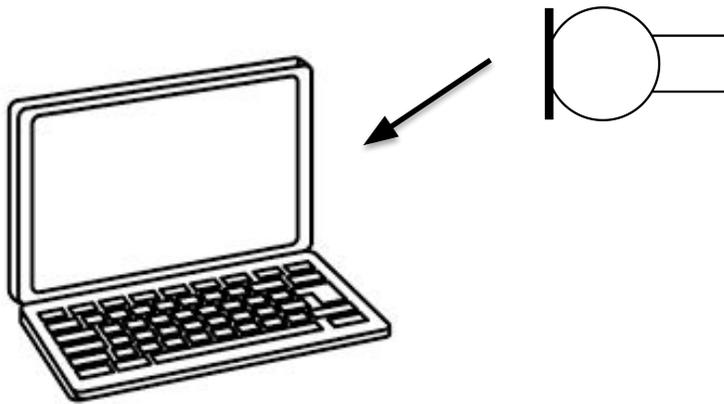- Digital-to-Analog Converter

- Playback Path

- Examples

Recap

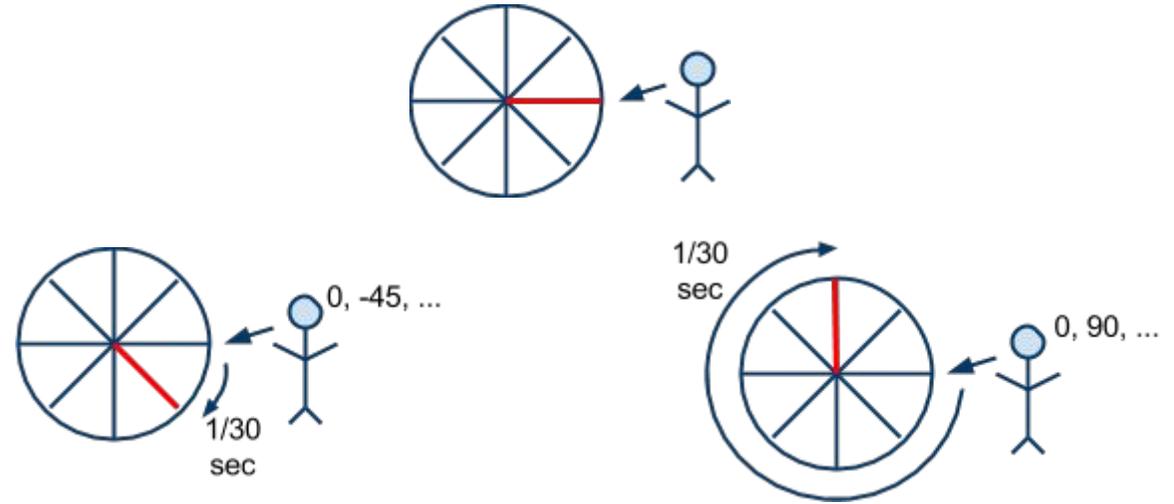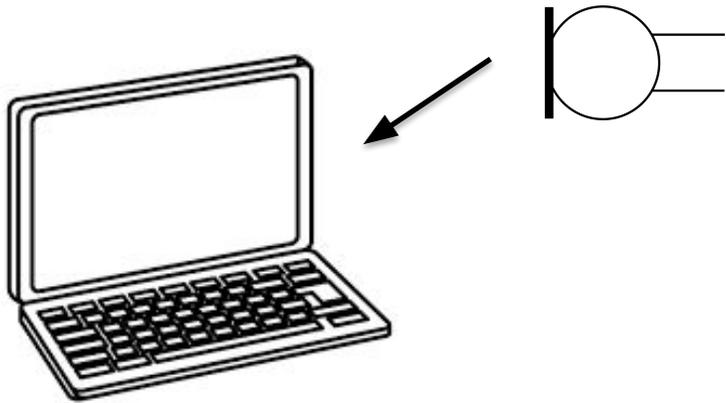Problem 1: not using all the range possible.

Solution: increase gain.

Problem 2: signal is biased to positive or negative range.

Solution: remove DC bias (e.g., add a capacitor)

Problem 3: missing important information.

Solution: sample faster!
But might not solve all problems!

Aliasing

We sample based on the 0~20KHz range
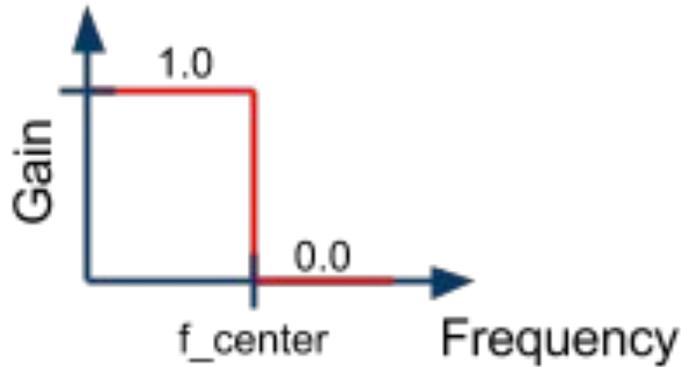But faster noises will also show up in this range!

Low Pass Filter

Ideal filter: pass *only* frequencies below our maximum.
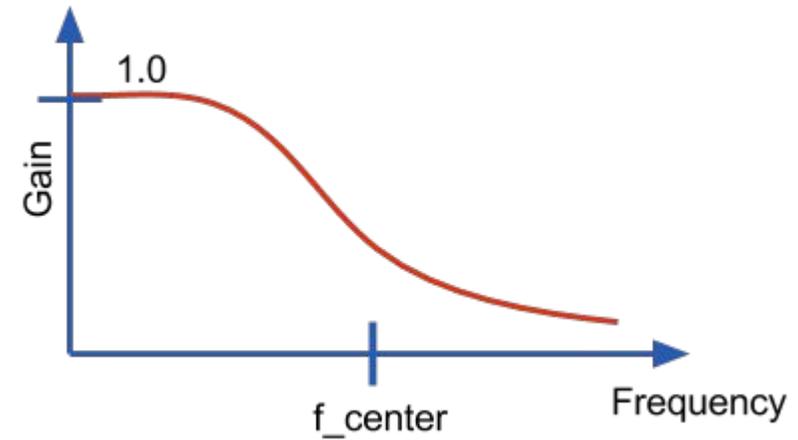
Real filter: tries to pass *only* frequencies below our maximum.

Low Pass Filter

0 Hz   20 KHz   1 GHz

Desired Frequency Range

Noise

Filter eliminates these frequencies before we even sample the signal!

Complete Input Pipeline

Mic. → Bias Correction → Low Pass Filter → Amplifier Gain = 1000 → 16-bit ADC 40 KHz

SPEAKER

?
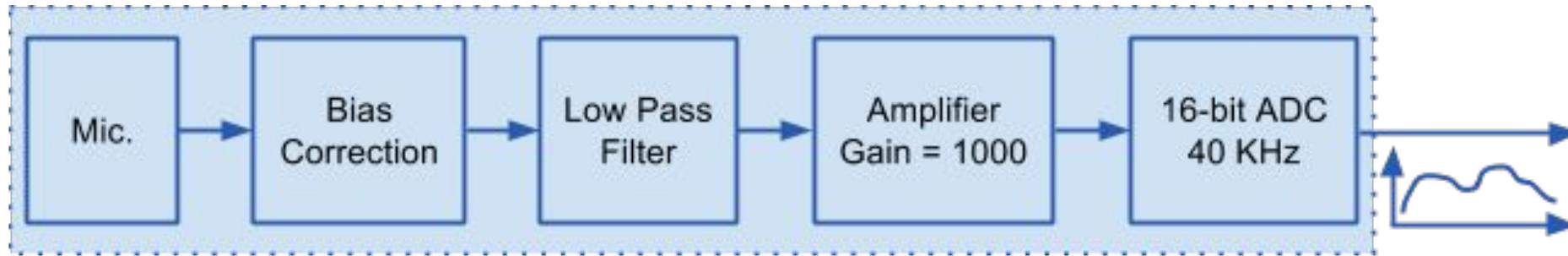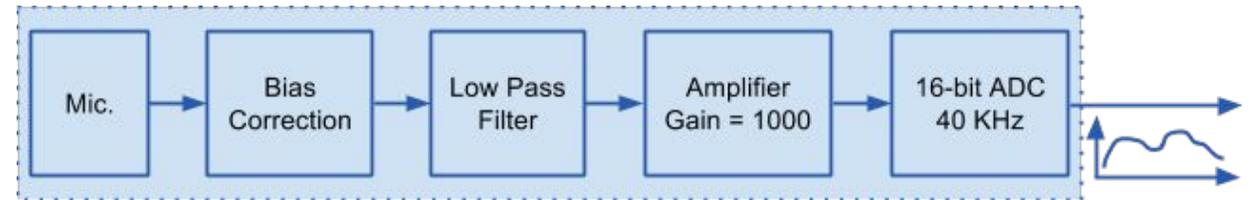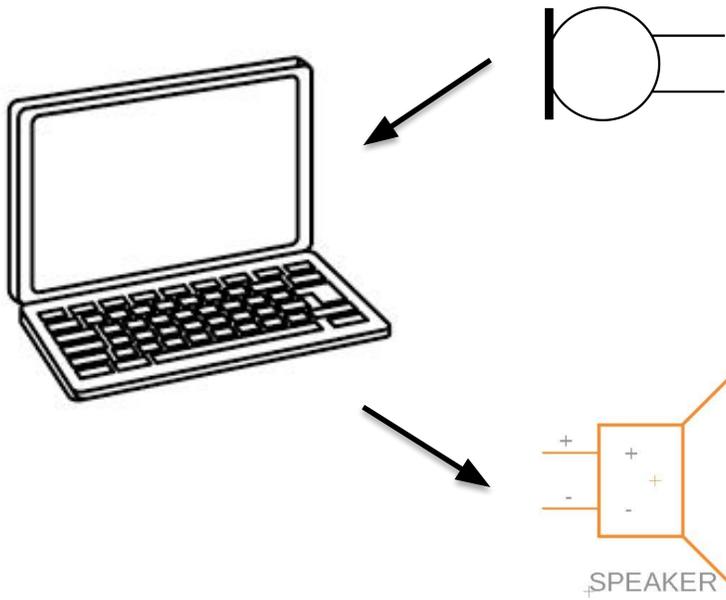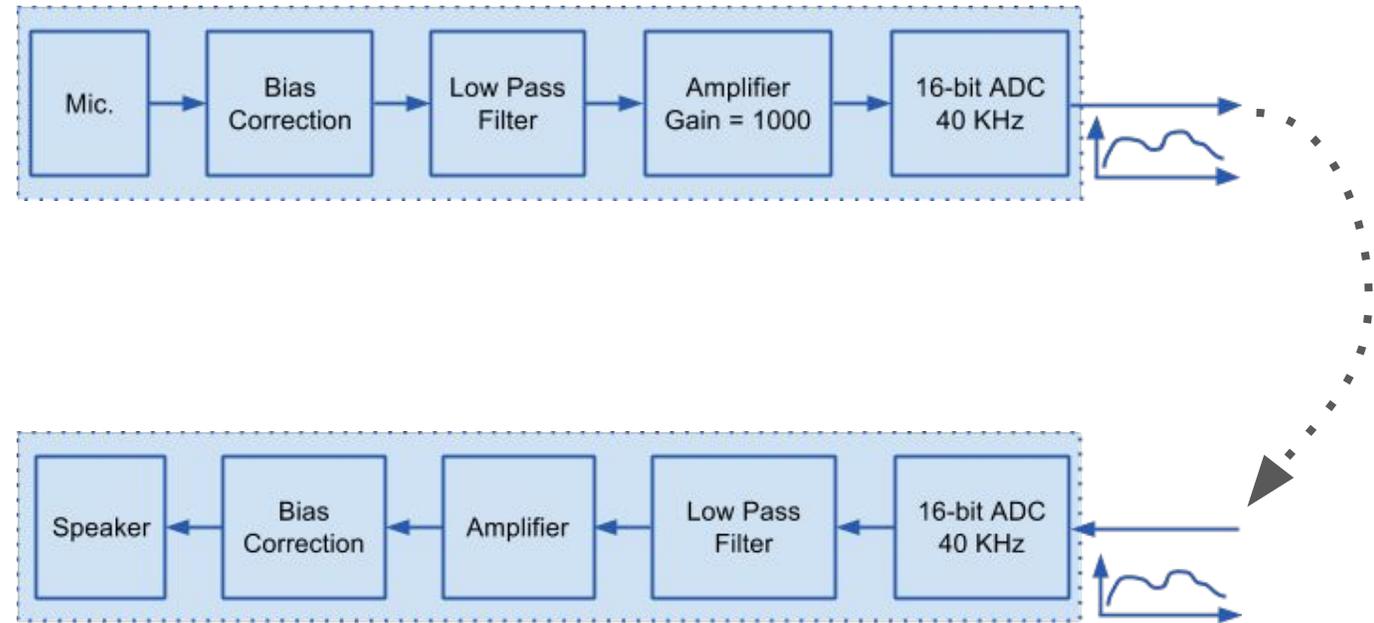
This is the playback path!

Output Pipeline

Digital-to-Analog Converter (DAC)

We do the inverse now:
- The DAC will sample our signal
- Process the input based on its range
- Adjust the range of output
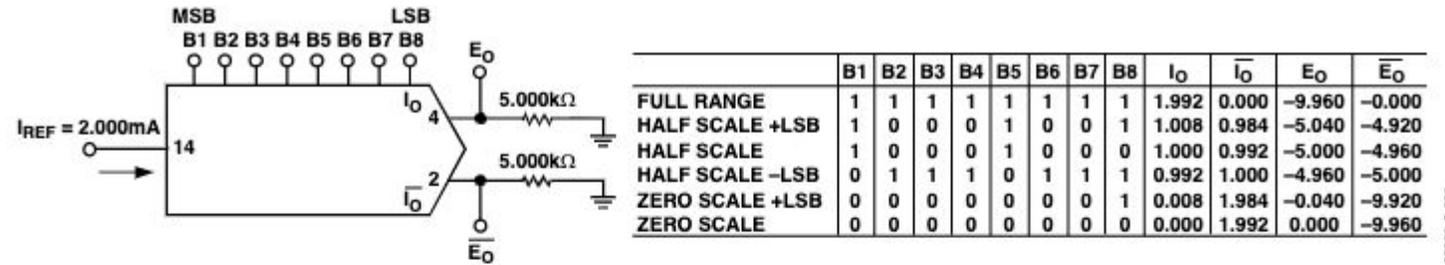
Figure 25. Basic Unipolar Negative Operation

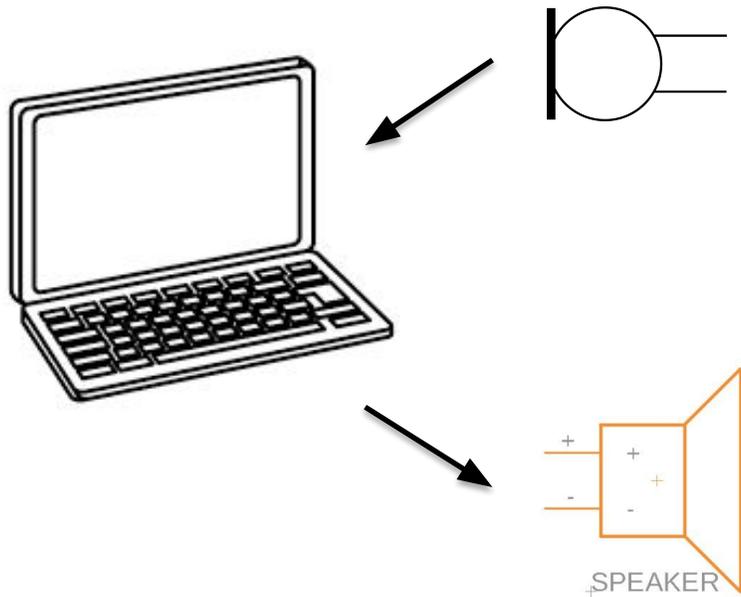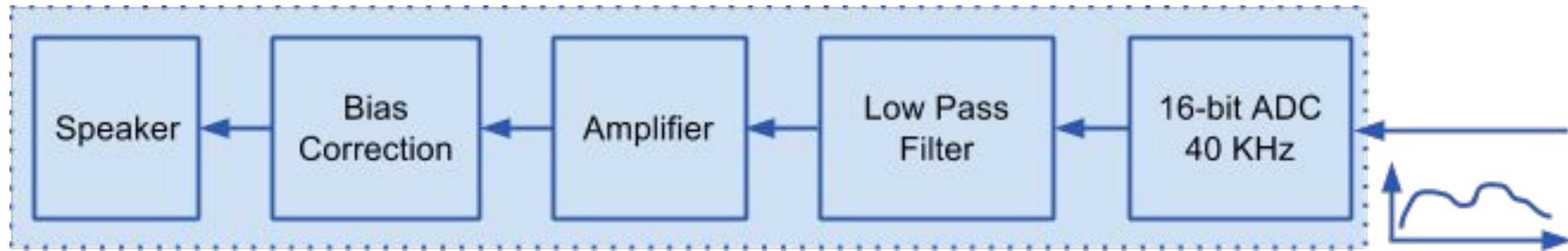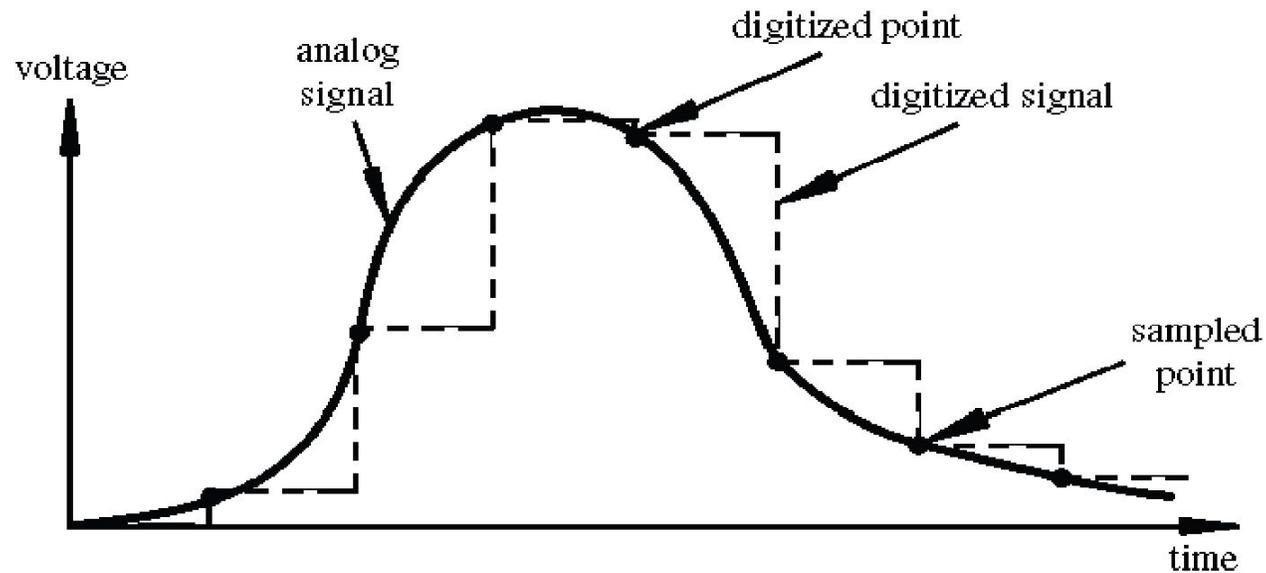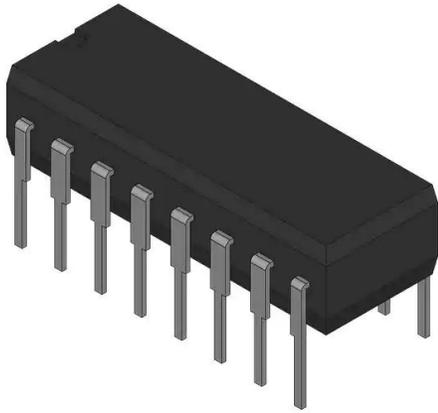|	B1	B2	B3	B4	B5	B6	B7	B8	I_O	$\overline{I_O}$	E_O	$\overline{E_O}$
FULL RANGE	1	1	1	1	1	1	1	1	1.992	0.000	−9.960	−0.000
HALF SCALE +LSB	1	0	0	0	1	0	0	1	1.008	0.984	−5.040	−4.920
HALF SCALE	1	0	0	0	1	0	0	0	1.000	0.992	−5.000	−4.960
HALF SCALE −LSB	0	1	1	1	0	1	1	1	0.992	1.000	−4.960	−5.000
ZERO SCALE +LSB	0	0	0	0	0	0	0	1	0.008	1.984	−0.040	−9.920
ZERO SCALE	0	0	0	0	0	0	0	0	0.000	1.992	0.000	−9.960
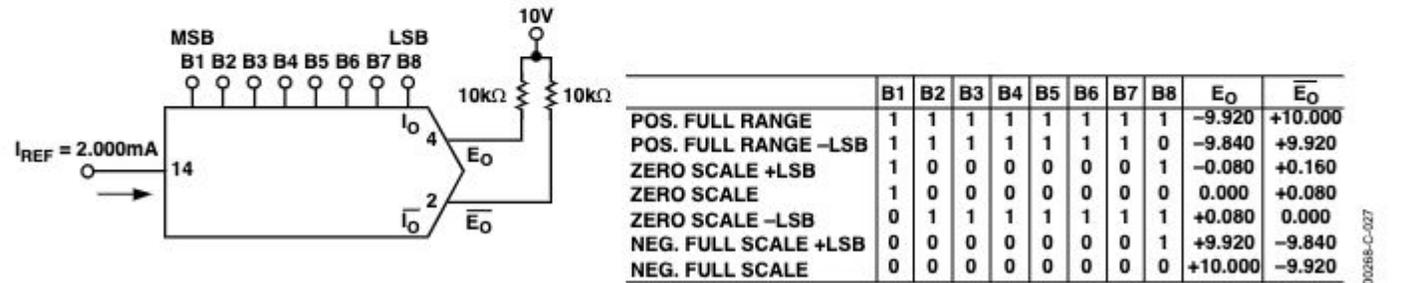
Figure 26. Basic Bipolar Output Operation

	B1	B2	B3	B4	B5	B6	B7	B8	E_O	$\overline{E_O}$
POS. FULL RANGE	1	1	1	1	1	1	1	1	−9.920	+10.000
POS. FULL RANGE −LSB	1	1	1	1	1	1	1	0	−9.840	+9.920
ZERO SCALE +LSB	1	0	0	0	0	0	0	1	−0.080	+0.160
ZERO SCALE	1	0	0	0	0	0	0	0	0.000	+0.080
ZERO SCALE −LSB	0	1	1	1	1	1	1	1	+0.080	0.000
NEG. FULL SCALE +LSB	0	0	0	0	0	0	0	1	+9.920	−9.840
NEG. FULL SCALE	0	0	0	0	0	0	0	0	+10.000	−9.920

(XCK/T0) PB0	1	40	PA0	(ADC0)
(T1) PB1	2	39	PA1	(ADC1)
(INT2/AIN0) PB2	3	38	PA2	(ADC2)
(OC0/AIN1) PB3	4	37	PA3	(ADC3)
($\overline{SS}$) PB4	5	36	PA4	(ADC4)
(MOSI) PB5	6	35	PA5	(ADC5)
(MISO) PB6	7	34	PA6	(ADC6)
(SCK) PB7	8	33	PA7	(ADC7)
$\overline{RESET}$	9	32	AREF	
VCC	10	31		
GND	11	30		
XTAL2	12	29		
XTAL1	13	28		
(RXD) PD0	14	27		
(TXD) PD1	15	26		
(INT0) PD2	16	25		
(INT1) PD3	17	24		
(OC1B) PD4	18	23		
(OC1A) PD5	19	22		
(ICP1) PD6	20	21		

SPEAKER

Examples

Video Playback Speed

$[S_0 \quad S_1 \quad S_2 \ldots \ldots \ldots S_N]$ 1: 20: 00

$[Z_0 \quad Z_1 \ldots \ldots Z_{N/2}]$ 0:40:00
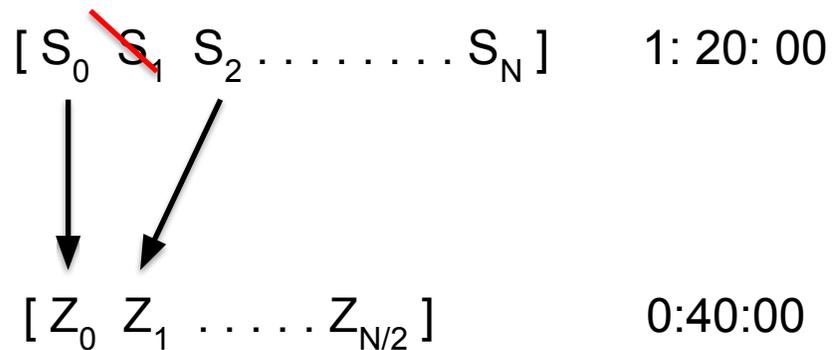
When you fast forward or slow down a video you change its playback time.

This changes the pitch of the audio…

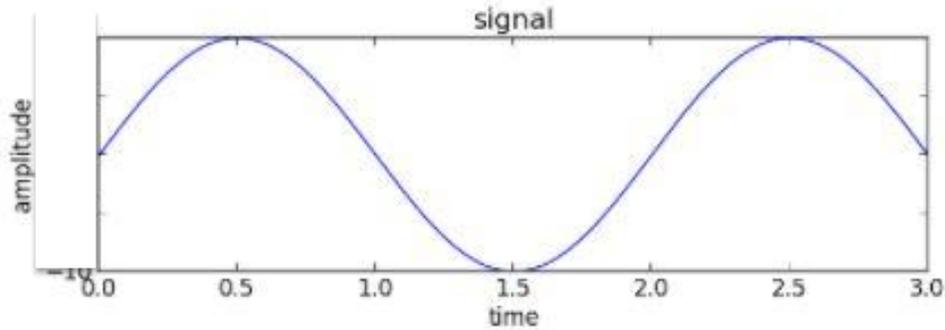So there is a limit up to which this can be done as it results in data loss.

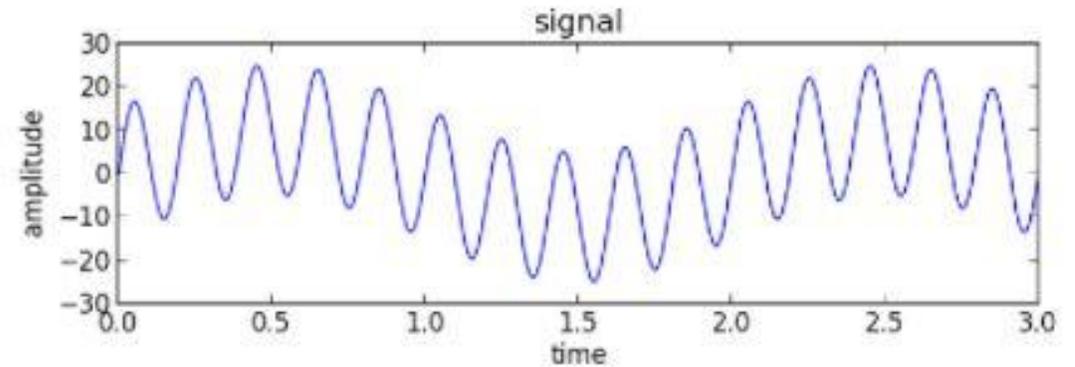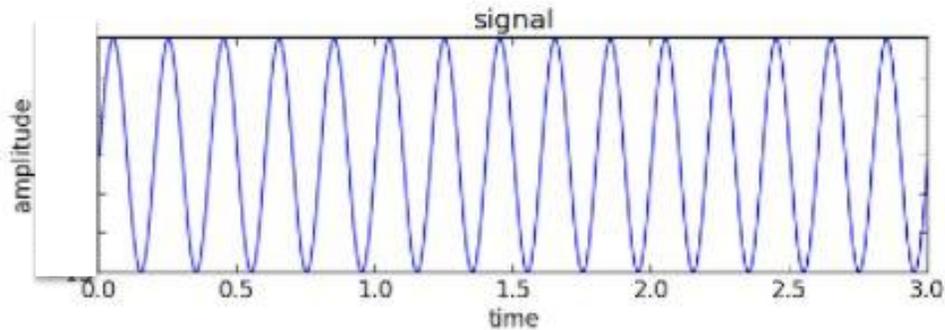Stream platforms are usually limited by a small factor (0.25x to 2x).
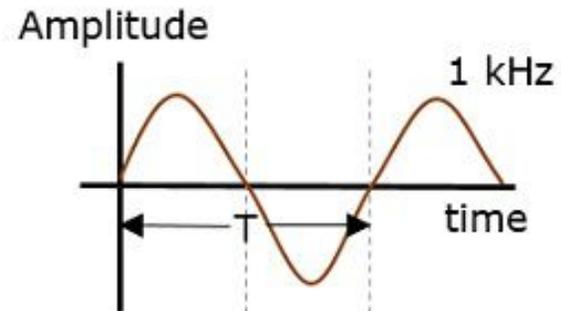
A

B

Consider A as temp of room in whole day
Consider B temp of space with people coming and leaving

Fourier Transform

Fourier Transform

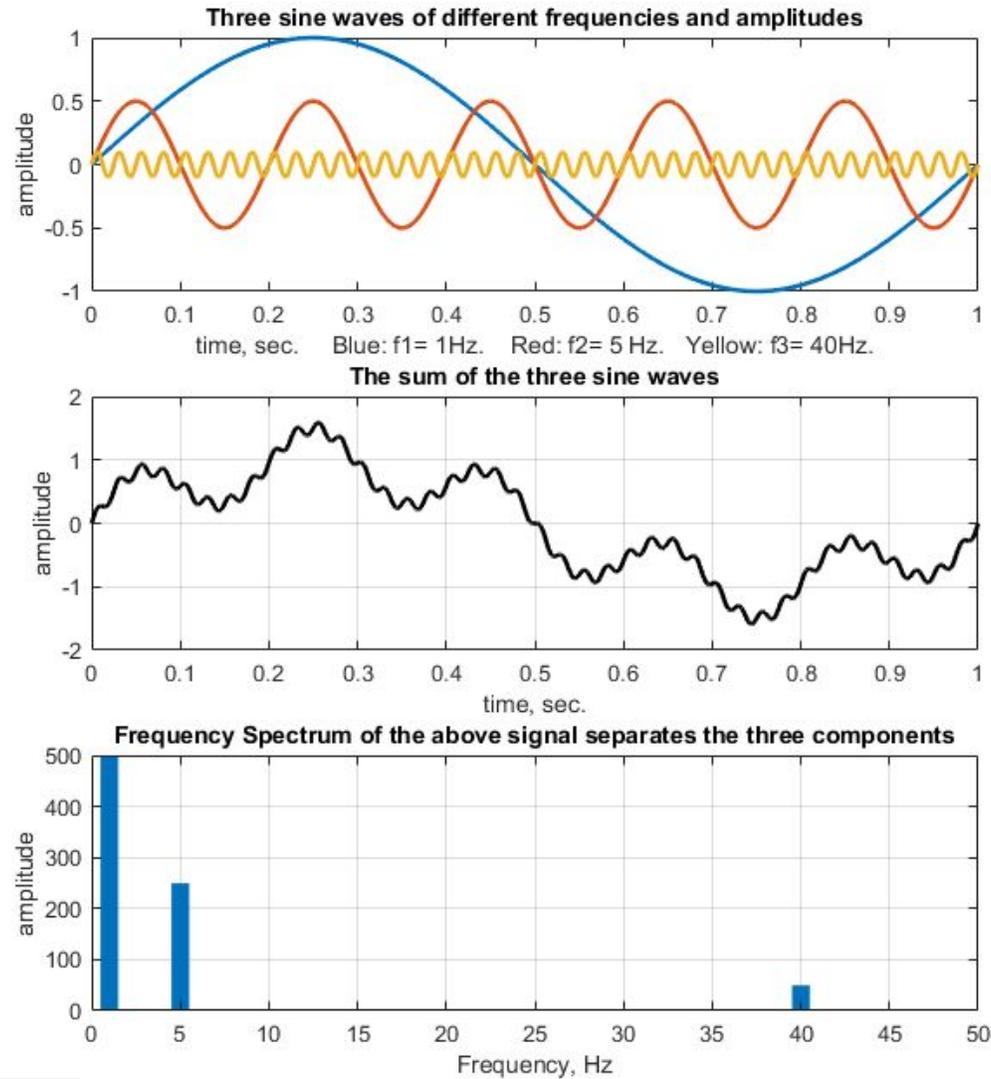Three sine waves of different frequencies and amplitudes
time, sec.   Blue: f1= 1Hz.   Red: f2= 5 Hz.   Yellow: f3= 40Hz.

The sum of the three sine waves
time, sec.

Frequency Spectrum of the above signal separates the three components
Frequency, Hz

5G Internet

https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8873669
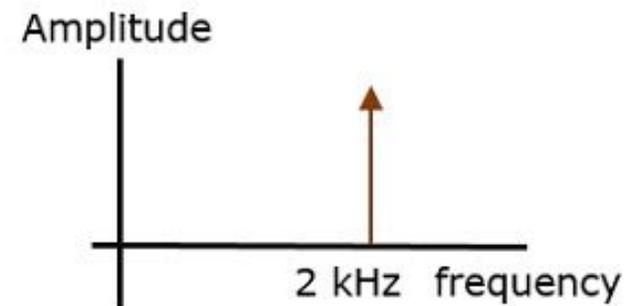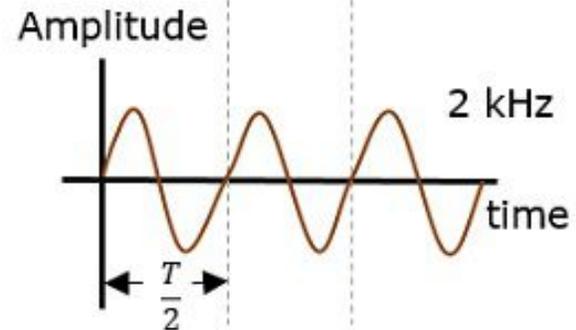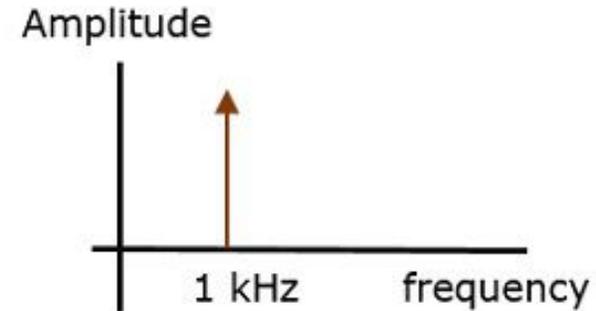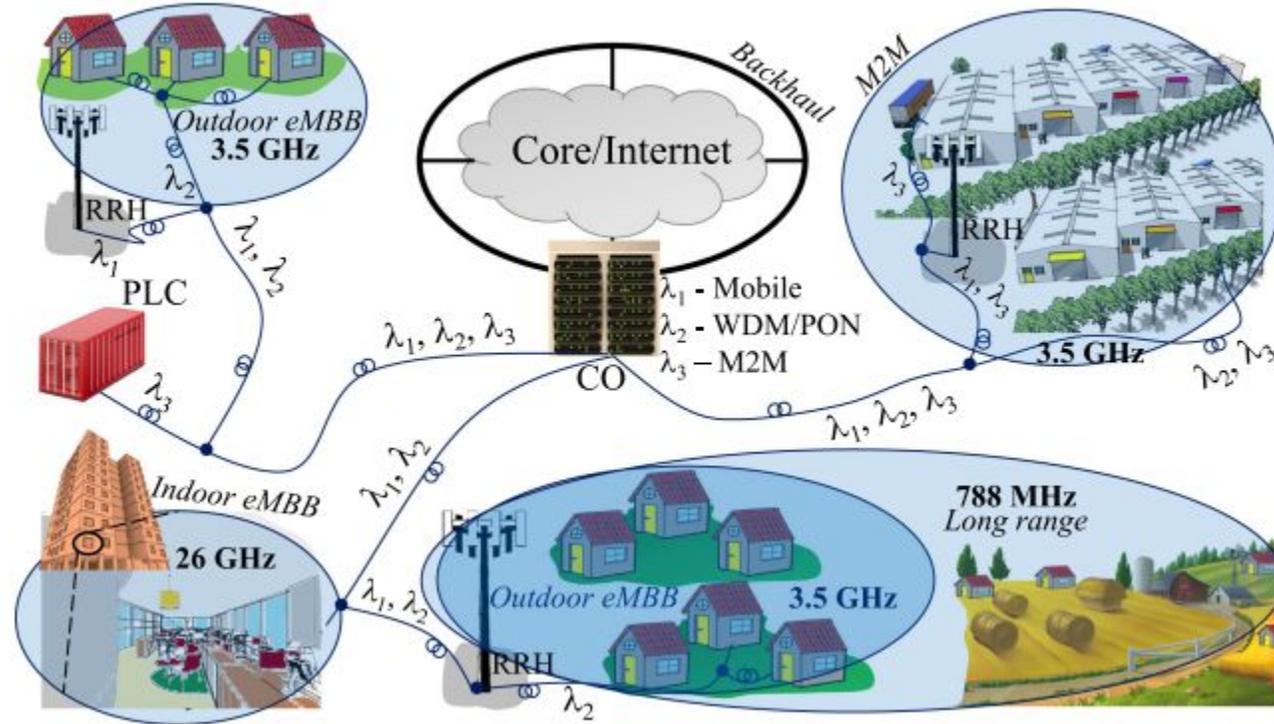
Optical Fiber Communication

$$H = \prod_{m=1,..end} H_m$$

https://www.mdpi.com/2076-3417/9/19/4192
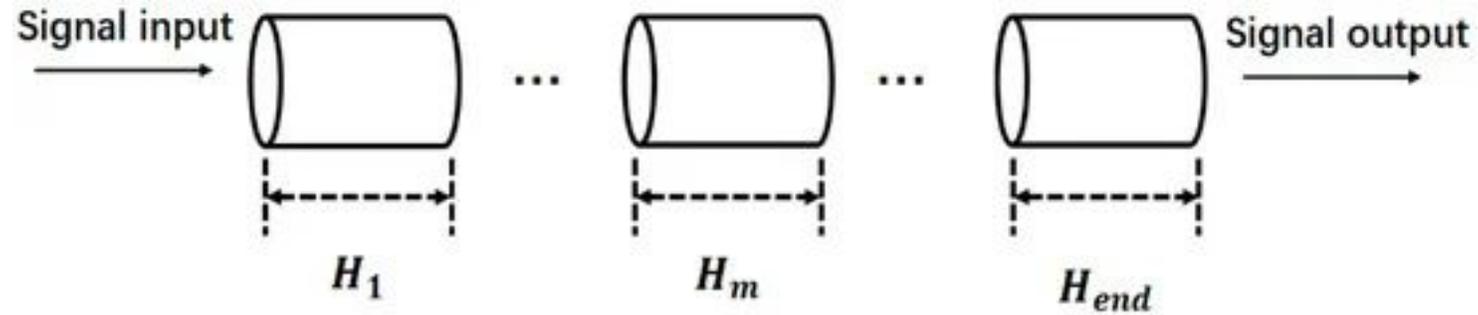
Low-Precision Deep Learning on FPGAs

https://ieeexplore.ieee.org/abstract/document/8532582

Genome Classification
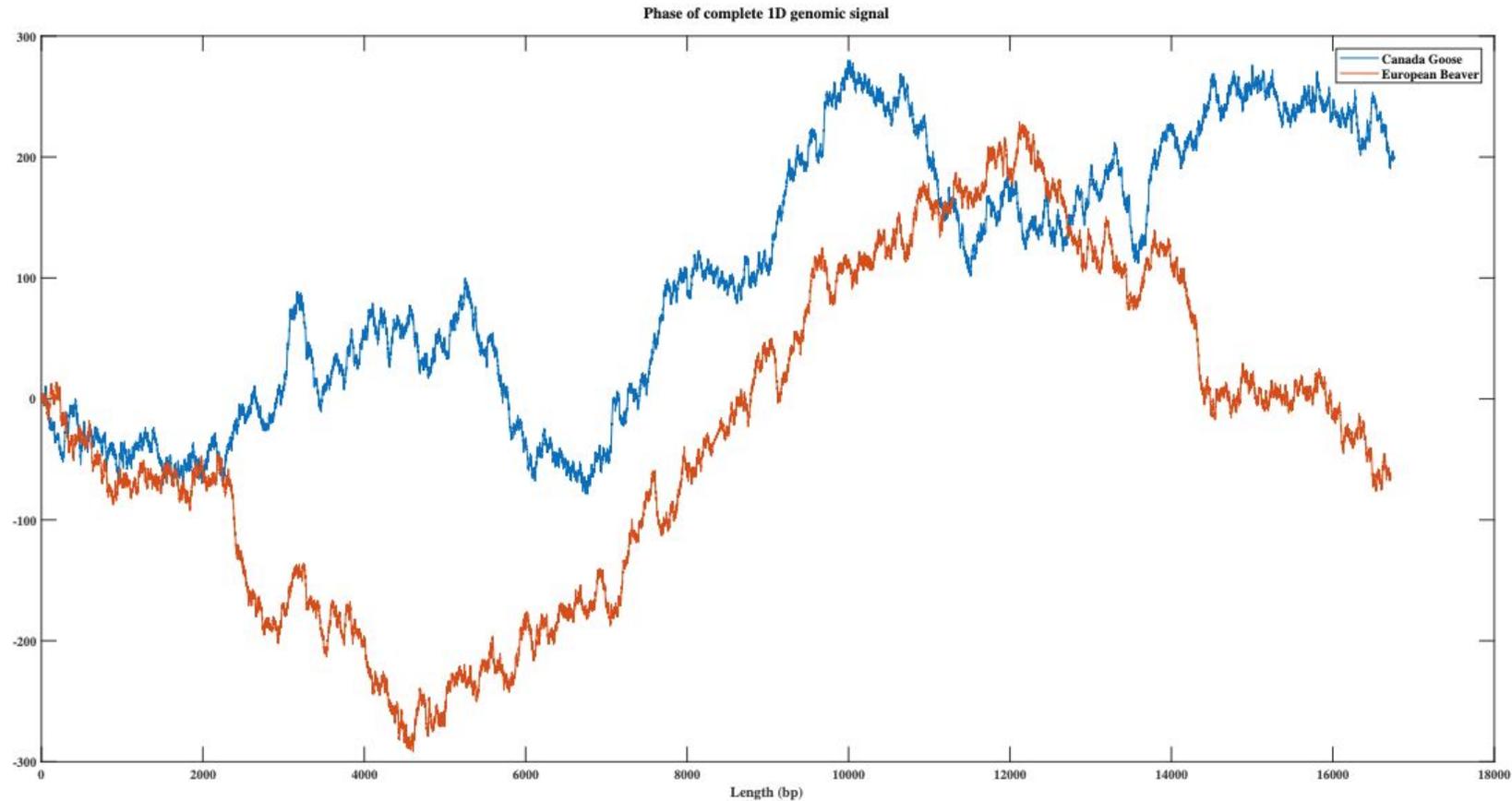

Phase of complete 1D genomic signal
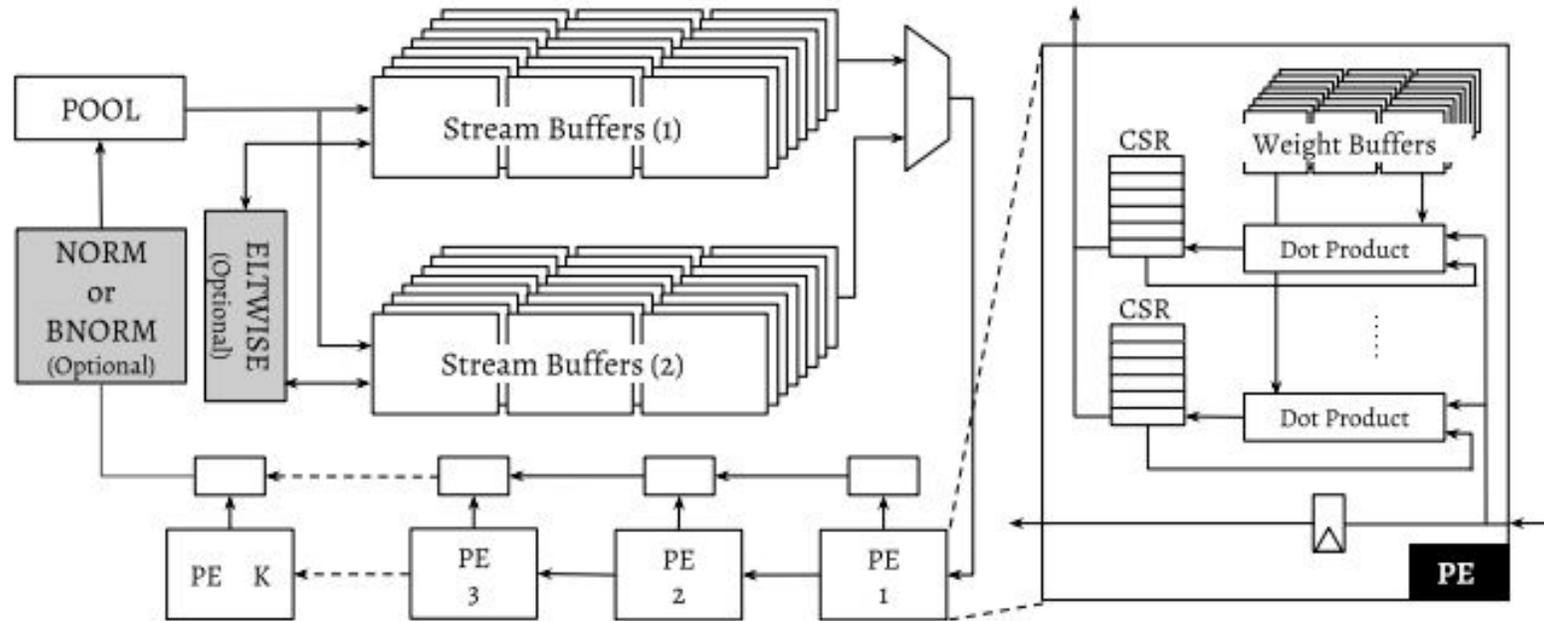
Fig. 2 Canada goose (blue, 16,760 bp) vs. European beaver (red, 16,722 bp) - comparison between the DFT phase spectra of their full mtDNA genomes

https://link.springer.com/article/10.1186/s12864-019-5571-y

See you next time :)

Q & A