

BIOMEDICAL ENGINEERING SUMMER SCHOOL, WILHELMSHAVEN 2018

INSTRUMENTATION, ACQUISITION AND SIGNAL PRO- CESSING FOR BIOSIGNALS

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**BAŞKENT
UNIVERSITY**



Contest

1. Introduction

1.1 What to do with the signal?

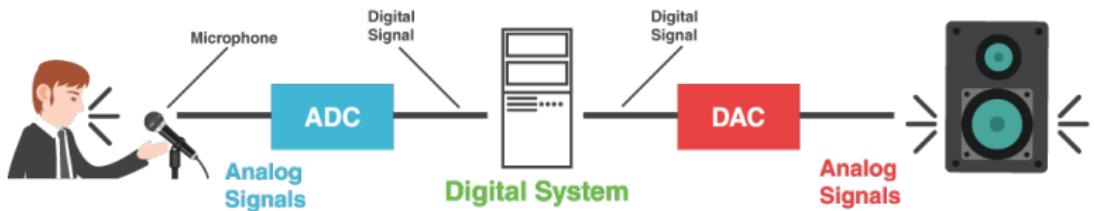
2. Examples of FT Applications

3. The Phonocardiogram Project

3.1 Basics of heart sound

4. Electronics Design Proposal

INTRODUCTION



Digital Signal Processing (DSP) basic scheme

What to do with the signal?

Once you have the signal in the digital domain, you can manipulate it, measure it and what ever you can imagine.

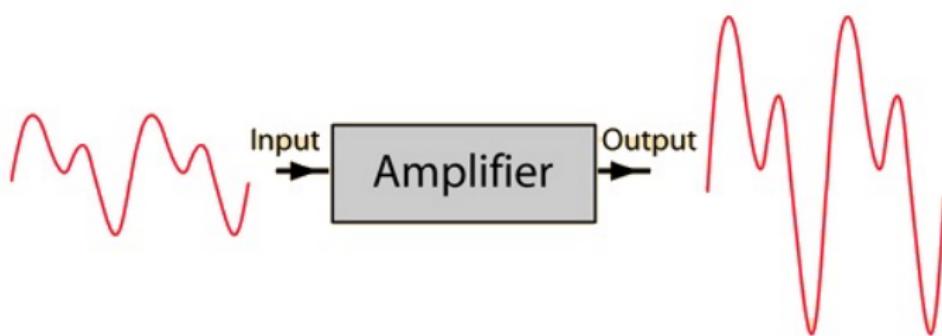
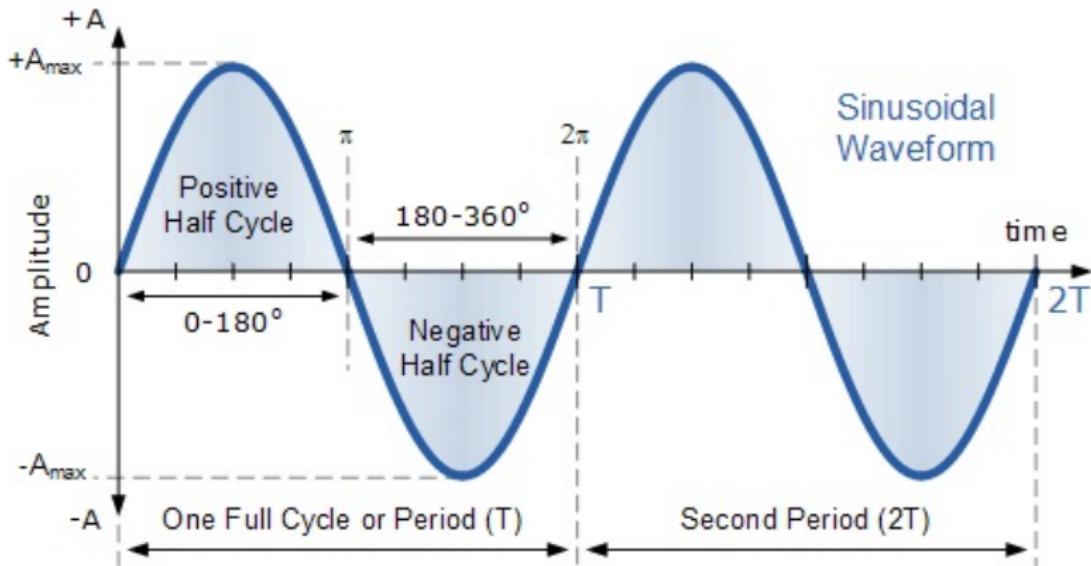
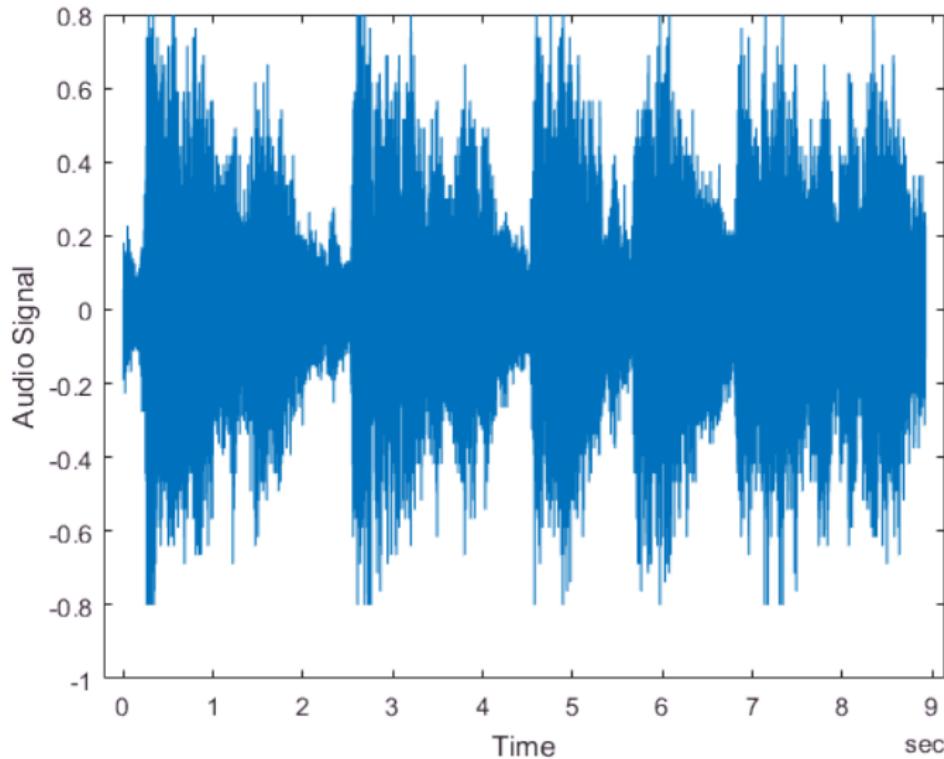


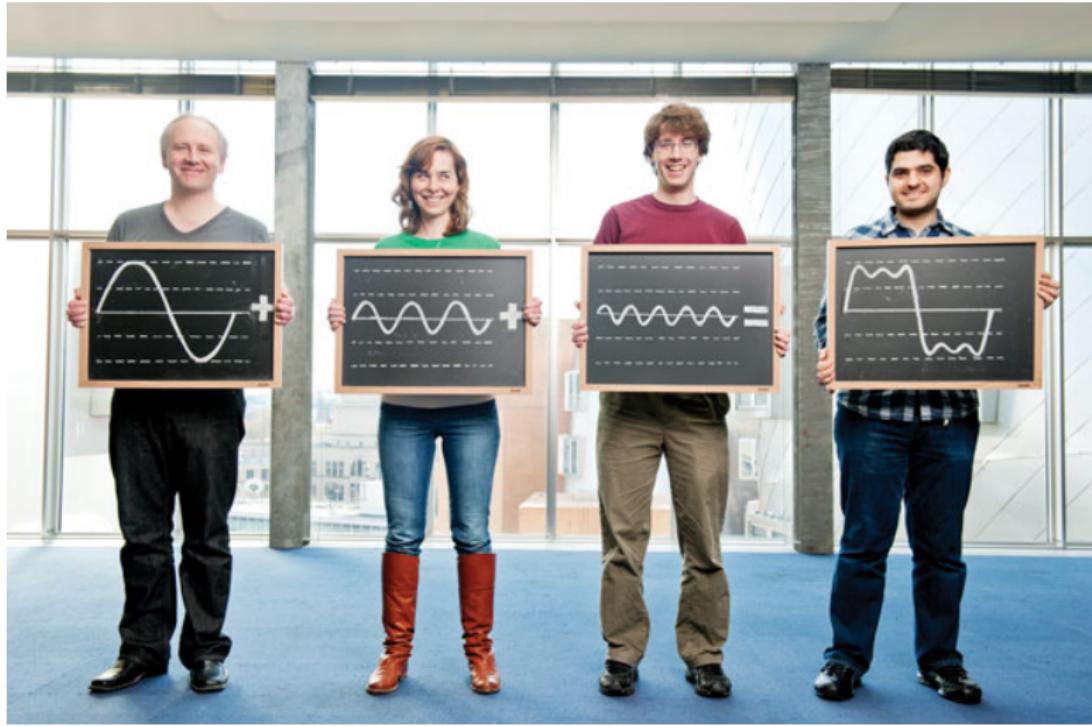
Figure: e.g. Amplifying a signal $y = 5x$



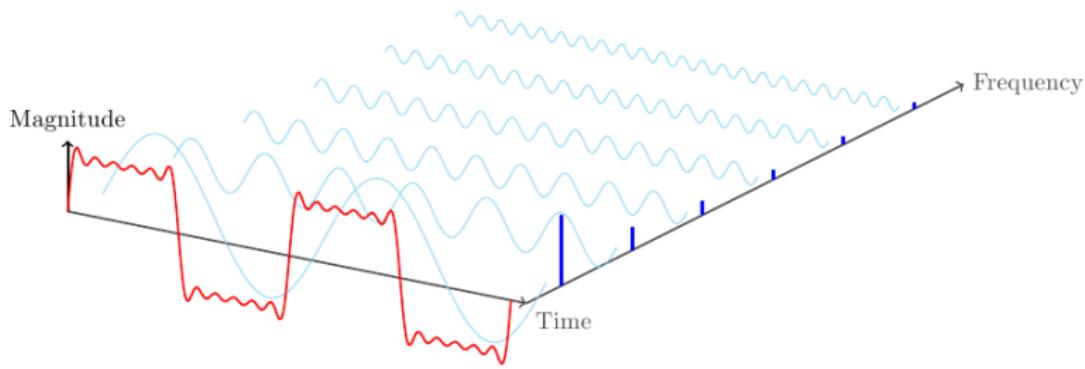
Measure it, also known as feature extraction.



How can we do that in more complex signals?



The Fourier Transformation (FT).

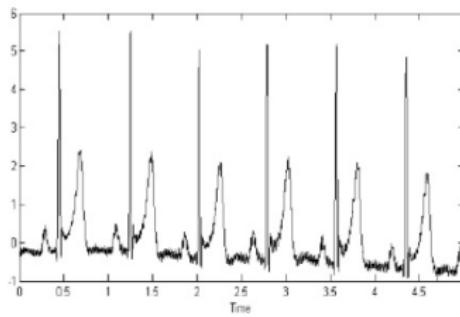
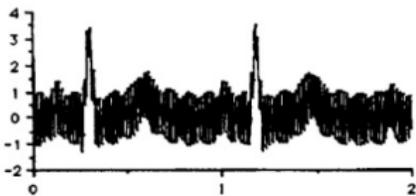


FT allows to identify frequency components upon complex signals.

EXAMPLES OF FT APPLICATIONS

Signal Filtering using Fourier Transform

- Rejection of the selected parts of the frequency spectrum $H(f)$



Notch Filter

A Real-time QRS Detection Algorithm

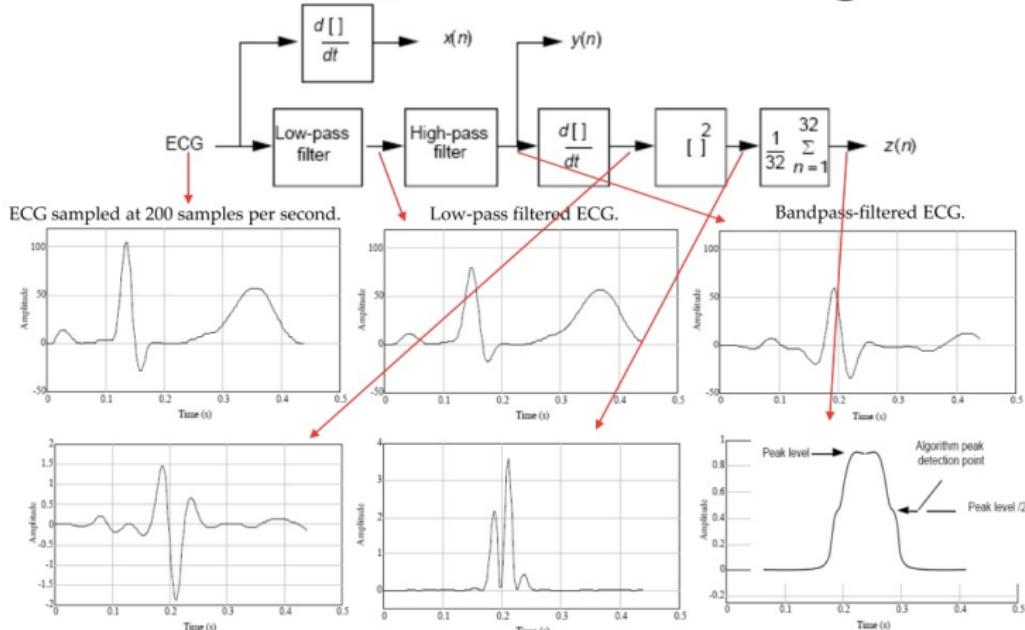
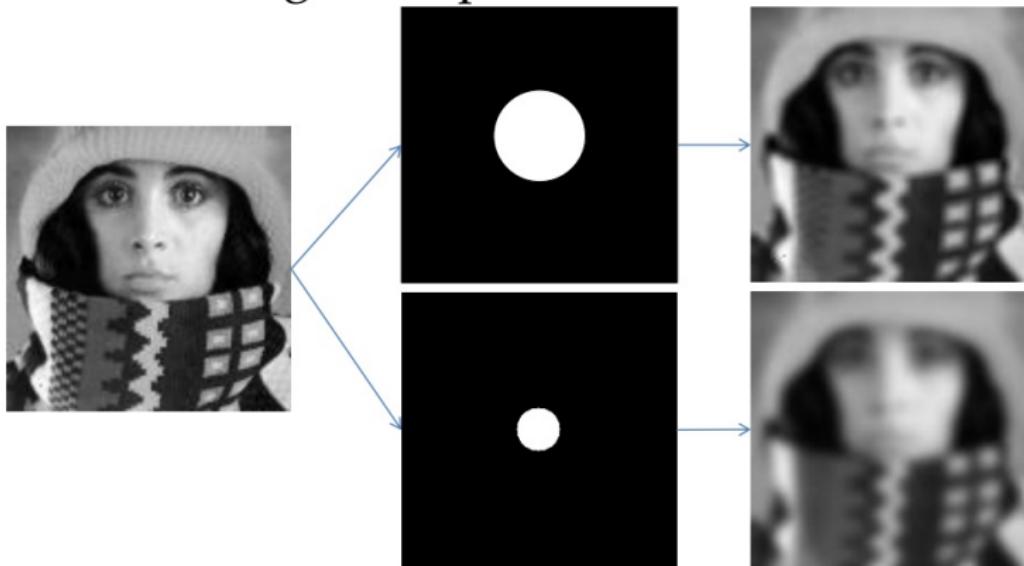


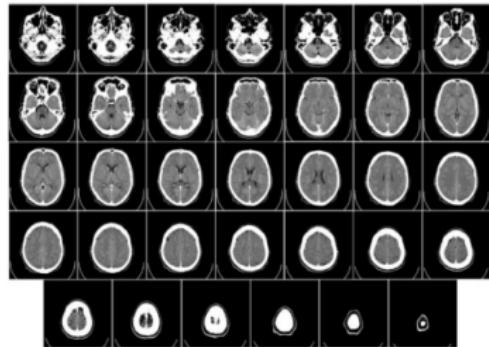
Image Processing using Fourier Transform

- Smoothing LPF operation;

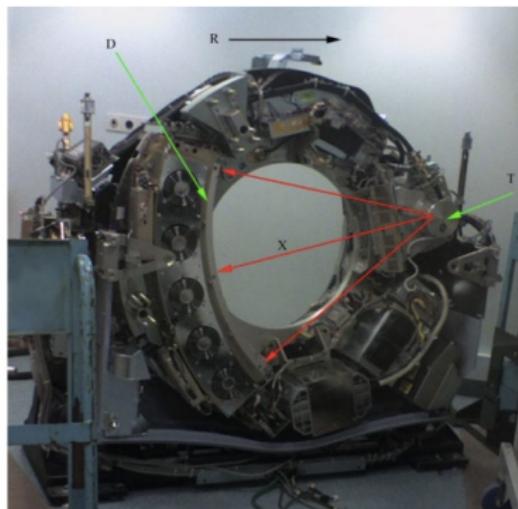
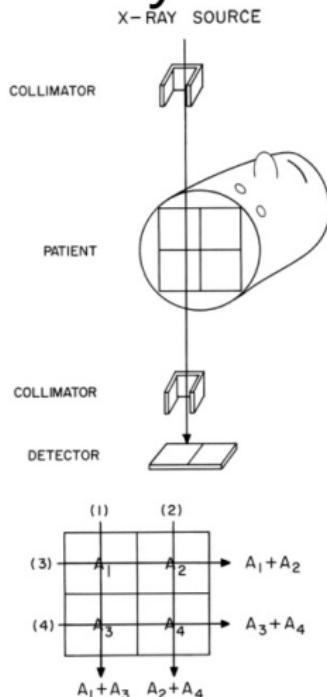


X-ray computed tomography

- computed tomography (CT scan) or computed axial tomography (CAT scan), is a medical imaging procedure that utilizes computer-processed X-rays to produce tomographic images or 'slices' of specific areas of the body.



X-ray computed tomography

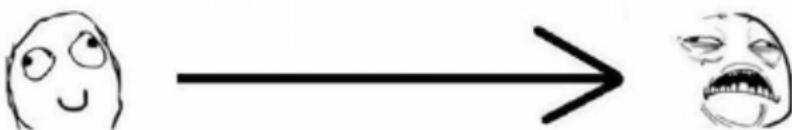


CT scanner with cover removed to show internal components.
T: X-ray tube, D: X-ray detectors
X: X-ray beam, R: Gantry rotation

Fourier Transformation

$$f(x,y) \longrightarrow F(U,V)$$

Four year Transformation



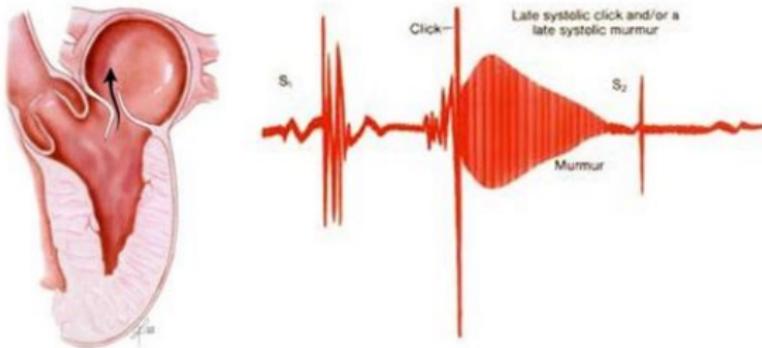
The diagram illustrates a 'Four year Transformation'. On the left, there is a cartoon drawing of a student's face with wide eyes and a neutral expression, labeled 'Engineering Student' below it. An arrow points to the right, leading to another cartoon drawing of a student's face, but this one is screaming with its mouth wide open and eyes closed, labeled 'ENGINEERING STUDENT' in all caps below it.

THE PHONOCARDIOGRAM PROJECT

PhonoCardioGram (PCG)

A PhonoCardioGram, also known as PCG, is a representation of heart's audio signal plotted against time.

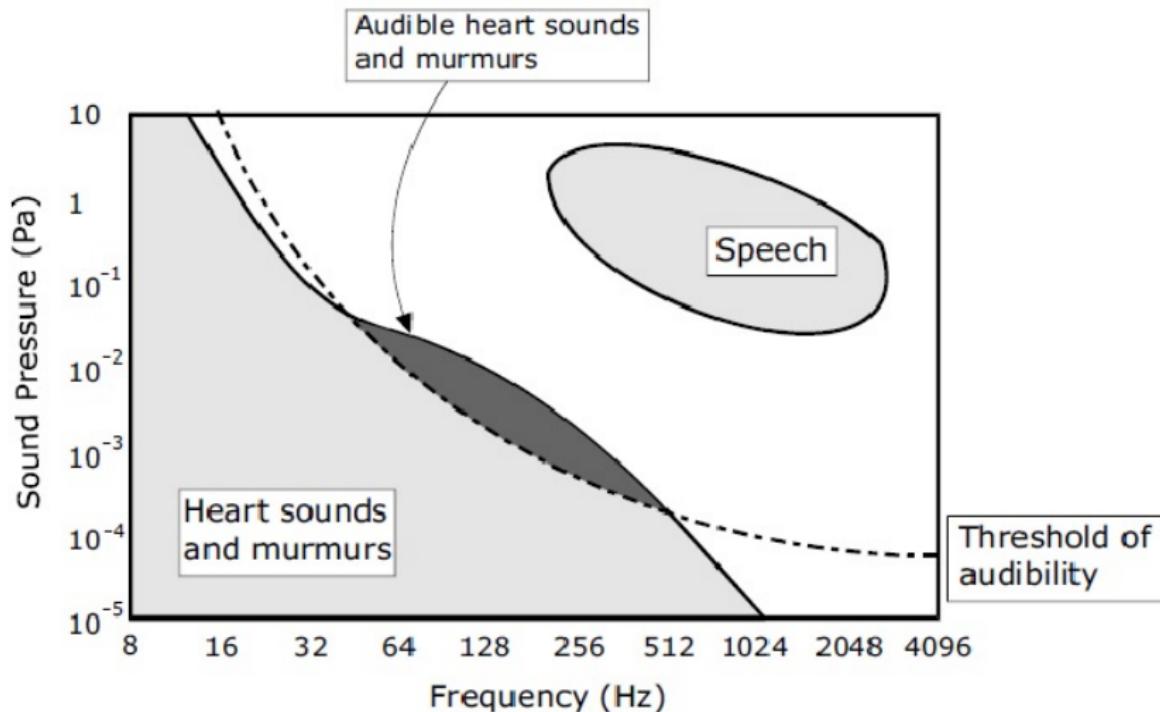
phonocardiogram



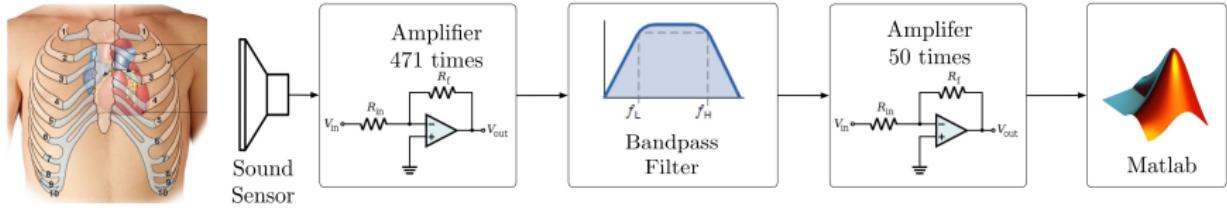
Which frequencies heart use to sing?

In order to acquire the heart's audio signal, is important to know where the heart's frequencies are.





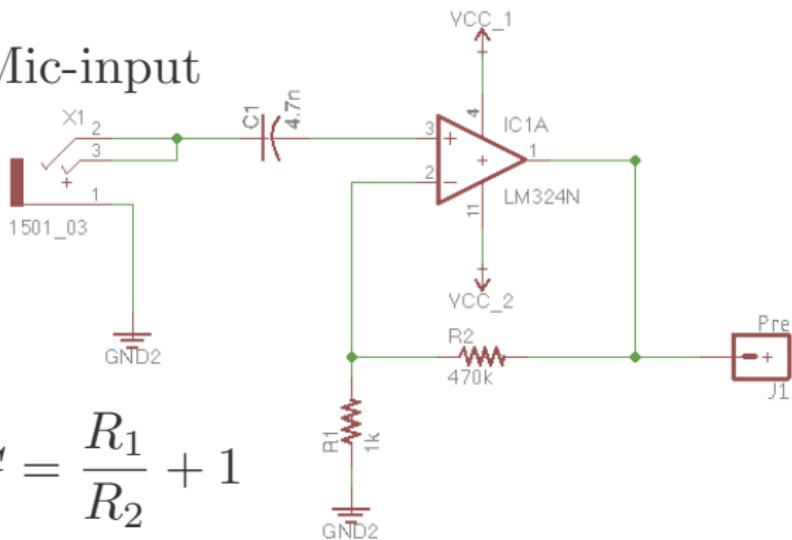
ELECTRONICS DESIGN PROPOSAL



Pre-Amp Stage

Non-inverting amplifier

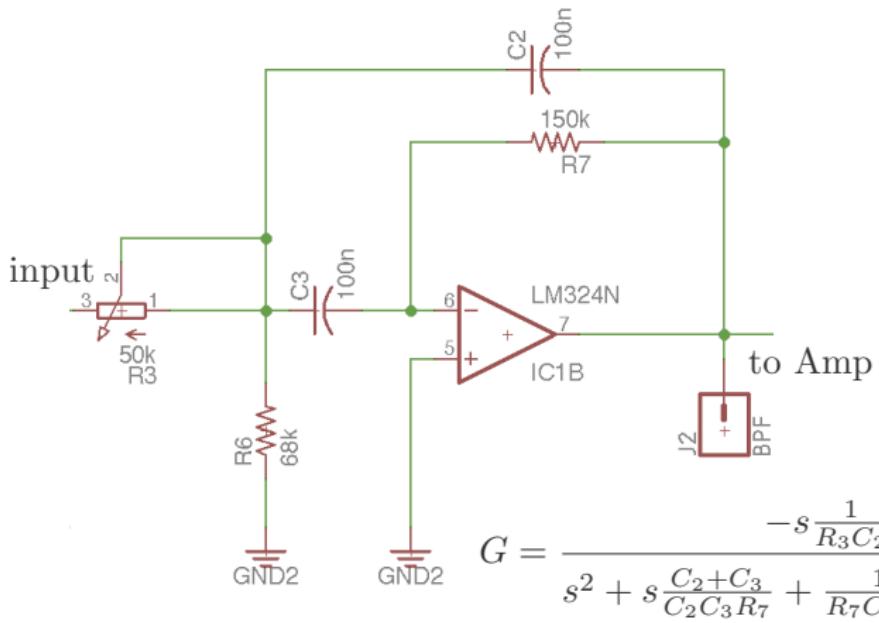
Mic-input



to Filter stage

Band-pass

BPF
Multiple feedback bandpass filter



$$G = \frac{-s \frac{1}{R_3 C_2}}{s^2 + s \frac{C_2 + C_3}{C_2 C_3 R_7} + \frac{1}{R_7 C_2 C_3} \left(\frac{R_1 + R_2}{R_1 R_2} \right)}$$

Filter design

The filter is defined by:

$$k = 2\pi f_0 C_3$$

$$C_2 = C_3$$

$$R_3 = \frac{1}{Hk}$$

$$R_6 = \frac{1}{(2Q - H)k}$$

$$R_5 = \frac{2Q}{k}$$

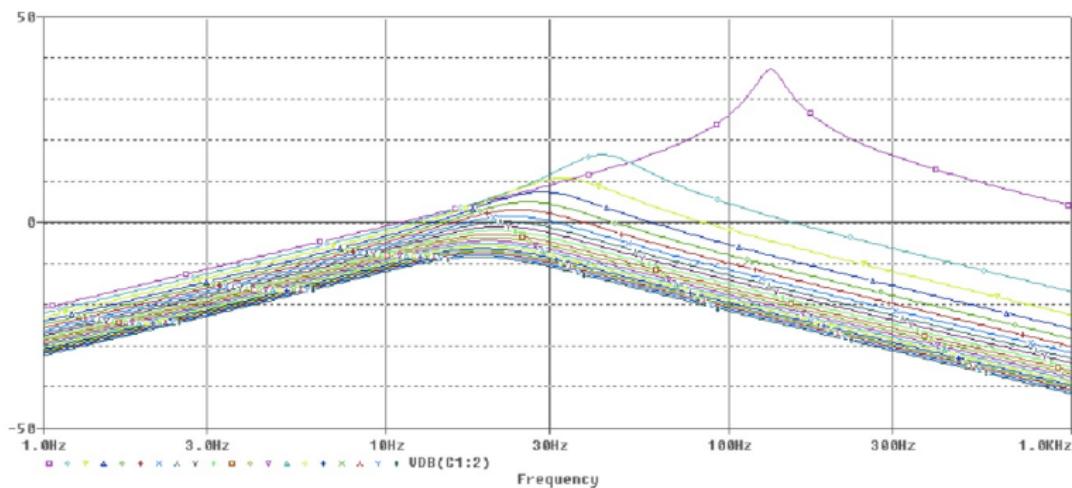
Design was tuned in:

$$Q = 2, f_0 = 33$$

$$C_2 = C_3 = 100nF$$

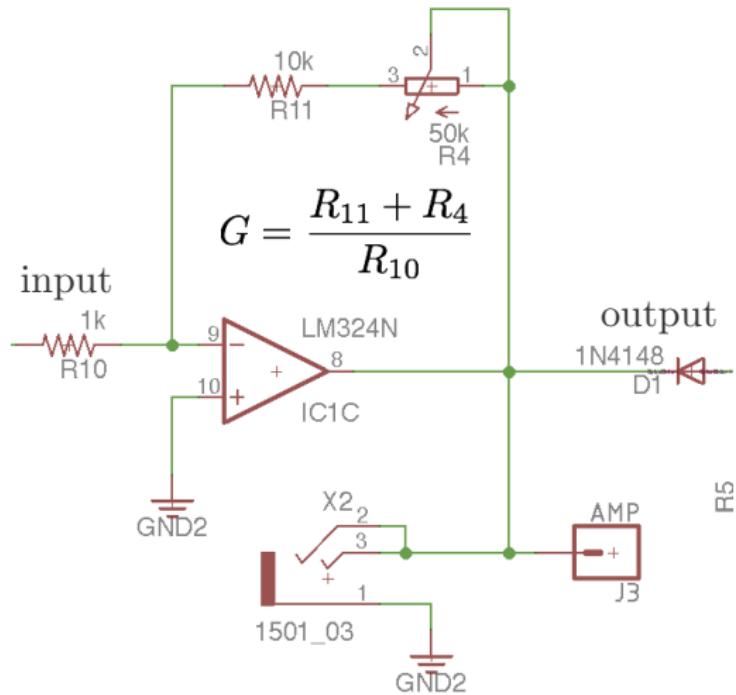
$$H = 2$$

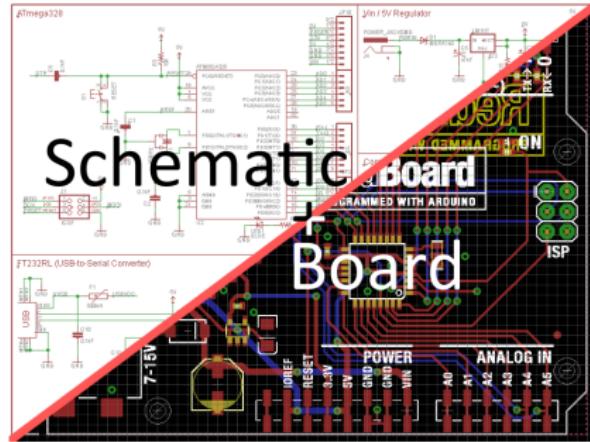
Filter's behaviour



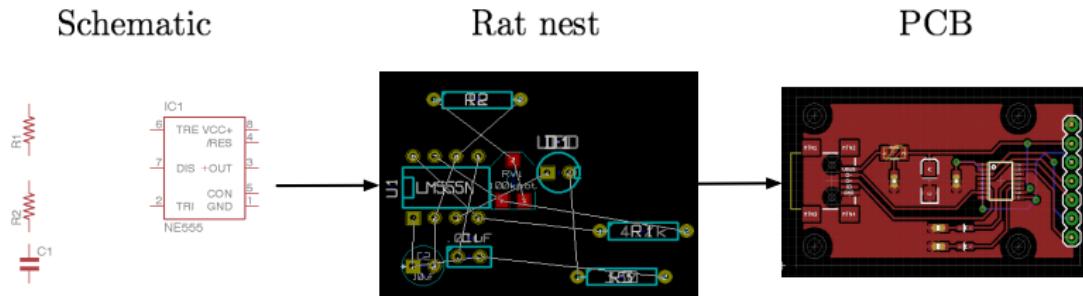
Inverting amplifier

Final Amplification





The IDE to create your own design



Eagle, OrCAD, TINA, Altium, ...



Lets built our PCB

