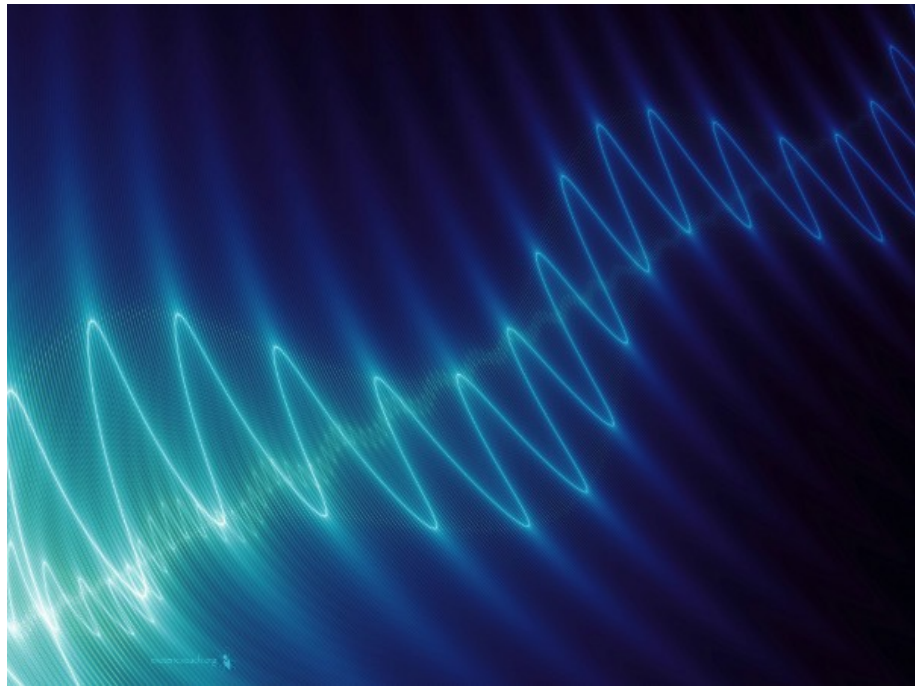


Bio-Electronic

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Projet ECG



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Bibliography

- [1] Electrical activity of the heart. [click here to see the vidéo.](#)
- [2] Electrocardiogram wiki. [click here.](#)
- [3] Find datasheet. [Alldatasheet.com](#) [click here.](#)
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- [8] T. Kugelstadt. Getting the most out of your instrumentation amplifier design. *Analog Applications Journal*, 2005.
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Introduction

Electrocardiography is the interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the surface of the skin and recorded by a device external to the body. The recording produced by this noninvasive procedure is an electrocardiogram (ECG).

As heartbeat is a vital parameter, it is important to observe its activity in many pathologies. An ECG is the best way to measure and diagnose abnormal rhythms of the heart. For example, in a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though not all areas of the heart are covered.

1.1 How does it work?

The ECG device detects and amplifies the tiny electrical signals on the skin that are caused when the heart muscle depolarizes during each heartbeat. At rest, each heart muscle cell has a negative charge, called the membrane potential, across its cell membrane. Decreasing this negative charge towards zero, via the influx of the positive cations, Na^+ and Ca^{++} , is called depolarization, which activates the mechanisms in the cell that cause it to contract.

During each heartbeat, a healthy heart will have an orderly progression of a wave of depolarisation. In Figure 1.1 & 1.2 the wave is triggered by the cells in the sinoatrial node, spreads out through the atrium, passes through the atrioventricular node and then spreads all over the ventricles (see the movie [1]). This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle.

Usually, more than two electrodes are used, and they can be combined into a number of pairs (For example: left arm (LA), right arm (RA) and left leg (LL) electrodes form the three pairs LA+RA, LA+LL, and RA+LL). The output from each pair is known as a lead. Each lead looks at the heart from a different angle. Different types of ECGs can be referred to by

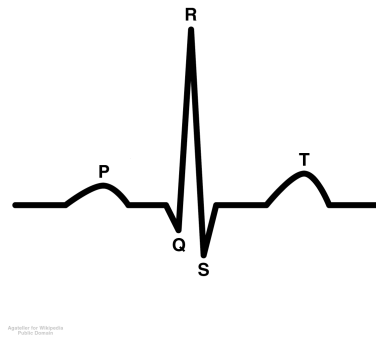


Figure 1.1: A typical ECG tracing of the cardiac cycle consists of a P wave, a QRS complex, a T wave and a U wave.

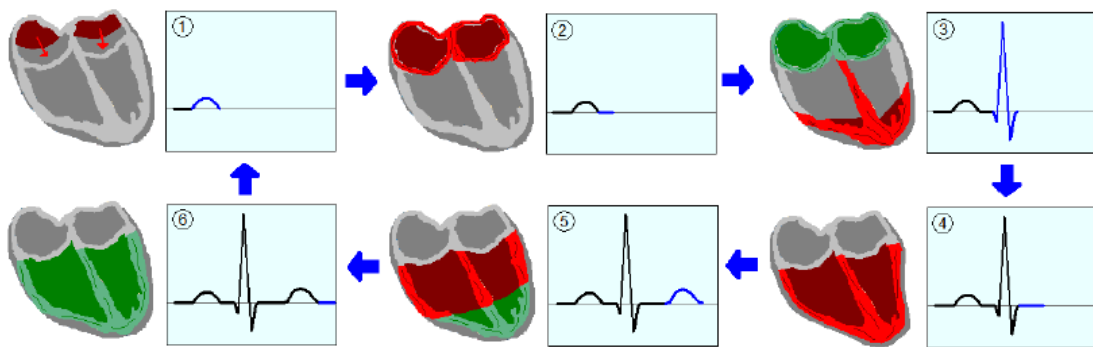


Figure 1.2: Electrical activity in myocardium

the number of leads that are recorded, for example 3-lead, 5-lead or 12-lead ECGs.

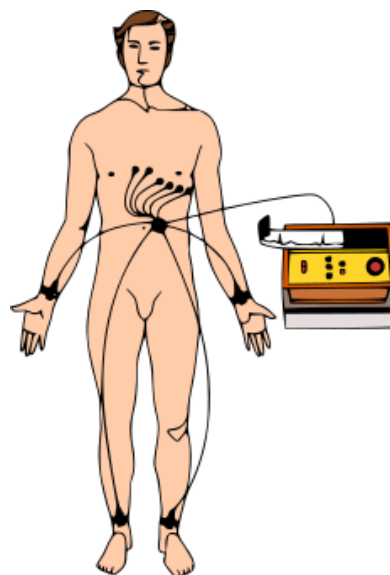


Figure 1.3: Electrodes placement for 12-lead ECG.

1.2 The problems

You have to design a simple portable ECG. The electrical signal to detect on the skin is a potential difference in the mV. You have to measure it with two (or more) electrodes. Of course, with the electrodes, you will get a highly noisy signal. You will have then to filter and amplify the signal to send it to a recording unit.

1. What are the frequencies that you want to record?
2. Which amplification gain do you need ?
3. Propose a typical acquisition - amplification -filtering chain.
4. Propose a solution to Common mode parasite.
5. Which devices will you use? Regarding the datasheet, comment in 5 lines your op-amp choice.
6. Propose a simulation Spice of your design and show gain,band-width,...
7. Implement your design with real components.
8. Use DSPIC to filter and visualize your signal.
9. In class, we briefly talked about the action potential of cells. For heart cells the action potential works somewhat different and is more complex. Find out how a heart cell works with respect to action potential and their cell membrane. Furthermore, research how a pacemaker works and how it interacts with the heart cells. Write a short summary (not more than 3 pages) and explain it works. Make use of formal references (including some peer reviewed journal papers).

Operational amplifier reminder

2.1 What can i do with OPA ?

- Amplifiers
- Filters
- Mix signals
- ...

See ⇒ [OP-Amp Tutorial](#)

2.2 Which Components should i use ?

See ⇒ [OP-Amp Tutorial](#)

- Opa2334 ⇒ op amp
- AD820 ⇒ op amp
- LTC1050 ⇒ op amp
- AD623 ⇒ instrumentation amplifier
- INA126 ⇒ instrumentation amplifier

ECG Design

3.1 Flowchart

In any project, it is important to understand and characterize the different signals to be measured. Then, one will isolate the different operations needed, and find the best way to implement them. In other words, we will go through these successive steps:

1. signal characterization;
2. identification of what should be done and in which order;
3. design a circuit meeting these constraints.

3.1.1 Signal characterization

Let's have a look at the different signals present at the entrance of our system [9], [8]:

- the ECG signals;
- interface skin - electrode;
- electro-magnetic interference

The ECG signal has already been discussed previously, so let's just remind the following facts: it consists of a signal around $5mV$ P-P which varies in frequency between $0.05Hz$ and $150Hz$.

The electrode is used as transducer, changing an ionic current into an electronic current. As so, it does not perfectly transmit the signal and distorts it a little bit. Typically, electrodes leads to a dc offset of hundreds of millivolts.

EMI interference can be caused by power lines, radio transmission, light tubes,... These interference are transmitted through coupling capacitors and are present as normal-mode or common mode signal. If we restrict to power lines, this interference is at $50Hz$ and can reach $1.5V$.

3.1.2 Flowchart creation

We basically have two types of signals present at the entrance of our system: the one we look for and all the others. We need to get rid of the second category without corrupting the signal we want to measure. Moreover, the ECG signal is very weak, so that it needs to be amplified.

We will then follow the following steps:

1. removal of the dc component of the signal, as well as the common-mode interference;
2. signal amplification, so that it reaches the desired amplitude output;
3. removal the frequencies above the upper frequency limit of our signal.

We remove the dc component and the common mode interference in the first step so that they do not lead to amplifier saturation. One can use an instrumentation amplifier to achieve this; an other trick is to use a resistor to drive the patient's body. This resistor can also be included in the feedback loop of the amplifier, for greater CMR (see [6]).

This order of operation can be summarized on Figure (3.1).

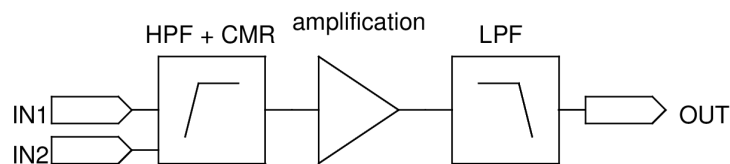


Figure 3.1: Flowchart

With respect to the previous section, the High-Pass Filter should be set at $0.05Hz$, while the Low-Pass Filter at $150Hz$ and the common mode attenuation should reach $100dB$.

Simulation SPICE

See ⇒ [LT Spice Tutorial](#)

DSPIC

We ask you to use a DSPIC from Microchip (DSPIC30F or DSPIC33F) to make the following things :

- Sampling the output signal from your instrumentation amplifier
- Filter noise using dsp library
- Use glcd to plot signal and show informations like bpm...
- In the repport a well commented code with explanations.

Practical organisation

6.1 Organisation and dates

- Form groups of 3 or 4 people
- 5 May : report and presentation

6.2 Report must contain :

- Answers to the problems of section 1.2
- Graphics from spice
- Problems still present in your design and how you could fix them.