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Contributions to Novel Methods in Electrophysiology Aided by Electronic Devices and Circuits

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1. Introduction

One of the challenges in the biomedical engineering domain is the bio-signal processing with special electronics devices and circuits, (Kutz, 2009). A parallel target is the remote medicine, which need mobile platforms for diagnosis and an internet link to ensure the telemedicine requirements, (Hung & Yuan-Ting, 2003). In this scope, the electronic devices and circuits play a crucial role. For instance, a noisy amplifier involves pseudo-signals, while an active filter can reject the undesired frequencies and adjust the useful signal, (C. Ravariu, 2010a).

The remote diagnosis centers, automate instruments for drug delivery (F. Ravariu et al., 2004) or mobile platforms for domestic applications (Woodward et al., 2001) are common targets accepted by the medical insurance companies form the world wide. The physician-patient remote interaction, so necessary in telemedicine, needs the development of various tools for home analysis, in order to be able to send all the collected tests to a database on Internet, (Fong, 2005). In real labs, more accurate results extracted from the electrophysiological measurements need the development of different hardware or software tools in order to send proper tests, without noise or pseudo-signals, to a medical center, (Babarada, 2010a).

On the other hand, this chapter has the following additional scopes: (i) it offers an alternative circuit for the noise rejection in electromyography and (ii) it represent a starting platform for new others electrophysiological signals recording, starting from cellular origin of the electrical biosignals (Sanmiguel, 2009) and the products can be easily used for learning in bioelectronics platforms, too (C. Ravariu, 2009b).

2. A mobile ECG platform

In this chapter is firstly proposed a simple and cheap platform for the electrocardiogram ECG recording on a Personal Computer PC. Why still ECG? Unfortunately, because the cardiovascular diseases are maintaining their first place in morbidity and mortality too, in many countries, (WHO Reports, 2008). The general electrical circuit for the ECG recording was adapted in order to be available for home applications. The amplified signal is then connected via the microphone muff to PC. A conversion of the input "noise" signal from

microphone, into an ECG trace is available on PC. In this way, the ECG becomes available, in the simpler mode directly on the computer screen, without any expensive tracer.
For instance this apparatus can become mobile with a laptop connection or with its own LCD display and can be used by customers without medical knowledge. Therefore, one of the original points of this chapter consists in the practical assembling of the hardware parts into a so called “mobile ECG platform”.
Two extreme facts occur in a medical center with the classical ECG equipment: 90% of the daily tests are false alerts. At the opposite extreme are placed the grave cases that don’t benefit in time about these kinds of centers. The mobile ECG platform provide in 1-2 minutes the main electrocardiograph shape, at home, and can alert the person if a dangerous situation is recorded, as emergency in cardiovascular diseases, (Drew, 2011).

2.1 The electronic components selection

The prime novelty of the paper isn’t a new spectacular circuit, because the standard ECG analog blocks are used, (Popa, 2006). But some distinct theoretical principles were collected together with the own implementation idea, to practically create this particular ECG. As integrated circuit, the TL 084 CN has been used, which possesses four operational amplifiers OP, figure 1.

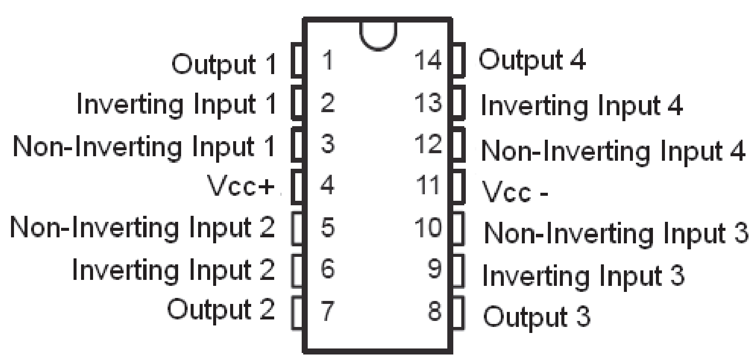


Fig. 1. The internal configuration of the integrated circuit TL 084 CN, (Texas Instruments, 2007)

The internal electronic scheme of each OP amplifier is represented in figure 2, (Texas Instruments, 2007).
The bipolar and JFET technologies combination conffers special performances, useful in biomedical applications. A first demand is the noise immunity , ensured by the JFET input configuration with extremely low gate currents as inputs. Then, the bipolar transistors are the most sensitive components in transconductance term, suitable for the biological signal amplification, as another demand.
The advantages of this circuit are: low power consumption, wide common-mode and differential voltage ranges, low input bias and offset currents, output short-circuit protection, high input impedance due to the JFET-input stage, common-mode input voltage range includes V_{CC}^{+}, high slew rates. The CN-suffix devices are characterized for operation from 0^0C to 70^0C, suitable for the human environment.
The interconnections among these operational amplifiers, since to produce the input signal amplification, besides to the low pass filter function, are presented in the design paragraph.

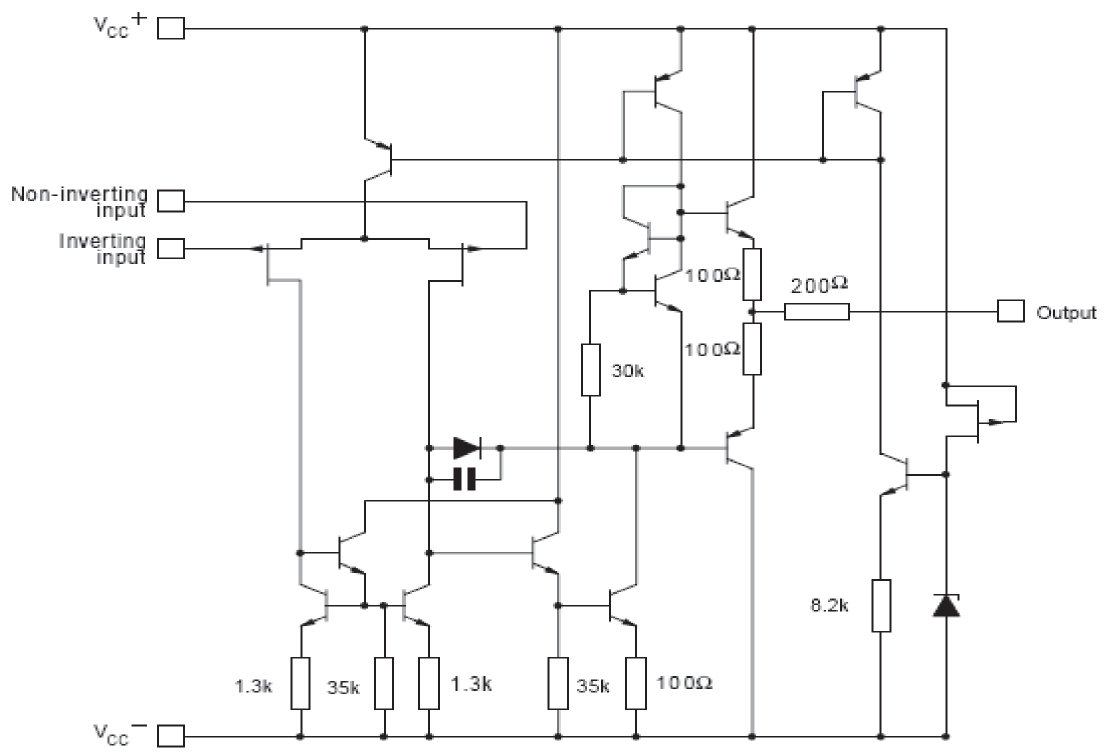


Fig. 2. The internal schema of one operational amplifier

2.2 The electronic circuit design

The work principle is based on the voltage difference measuring between two electrodes applied on the chest skin in respect with a third electrode – the reference electrode applied on the left hand skin. The electrodes are simple metal plates. For a smaller contact resistance, an electrolyte or gel is applied onto the electrode.

In this scope, an instrumentation amplifier function was made up from three previous operational amplifiers, figure 3.

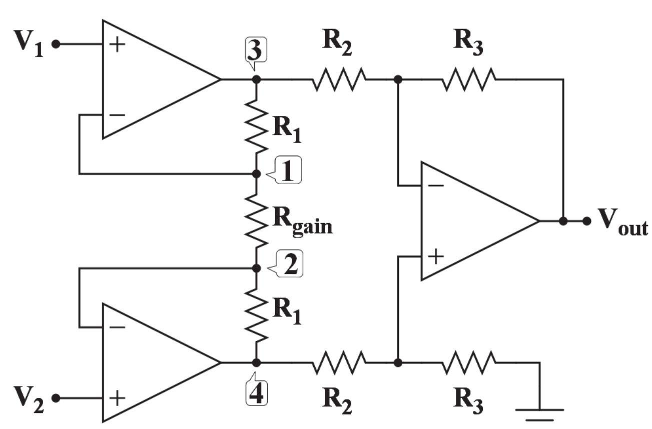


Fig. 3. The design of the amplifier

This circuit is constructed from a buffered differential amplifier stage with three new resistors, linking two buffer circuits together, (Rusu, 2008). All resistors have equal values, excepting for R_{gain}: $R_1=R_2=R_3=R$. The negative feedback of the upper-left operational amplifier causes the voltage in the point 1 to be equal with V_1. Likewise, the voltage in the point 2 is held to a value equal with V_2. This establishes a voltage drop across R_{gain} equal to the voltage difference between V_1 and V_2. That voltage drop causes a current through R_{gain}; since the feedback loops of both operational amplifiers draw no current on inputs, the same amount of current through R_{gain} must be going through two R_1 resistors, above and below it. This produces a voltage drop between the points 3 and 4 equal to:

$$V_3 - V_4 = (V_1 - V_2)\left(1 + \frac{R_1 + R_2}{R_{gain}}\right) \tag{1}$$

The regular differential amplifier on the right-hand side of the circuit then takes this voltage drop between points 3 and 4 and amplifies it:

$$V_{out} = (V_4 - V_3)\frac{R_3}{R_2} \tag{2}$$

The gain becomes 1, assuming again that all "R" resistors are of the same value. Although this method looks like a cumbersome way to build an instrumentation amplifier, it has the distinct advantages of possessing extremely high input impedances on the V_1 and V_2 inputs, because they connect straight into the non-inverting inputs of their respective operational amplifier and adjustable gain that can be set by a single resistor. The global gain of the amplifier results from eq. (1) and (2), taking into account that R_1=R_2=R_3=R:

$$A_v = \left(1 + \frac{2R}{R_{gain}}\right) \tag{3}$$

Because there are very small voltage differences, there is also a low pass filter added in one branch of the instrumentation amplifier, fig. 4.

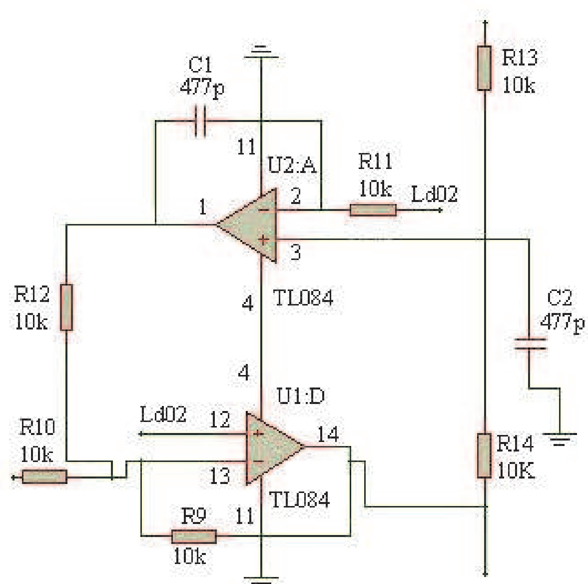


Fig. 4. Low pass active filter with operational amplifiers

The advantage of this circuit is that it is powered from only one 9V battery, the 0 level is at $V_{CC}/2$. The $V_{CC}/2$ level is given by one simple resistor divider, followed by a buffer.
The final schema used for the hardware implementation of the mobile ECG platform is available in figure 5.

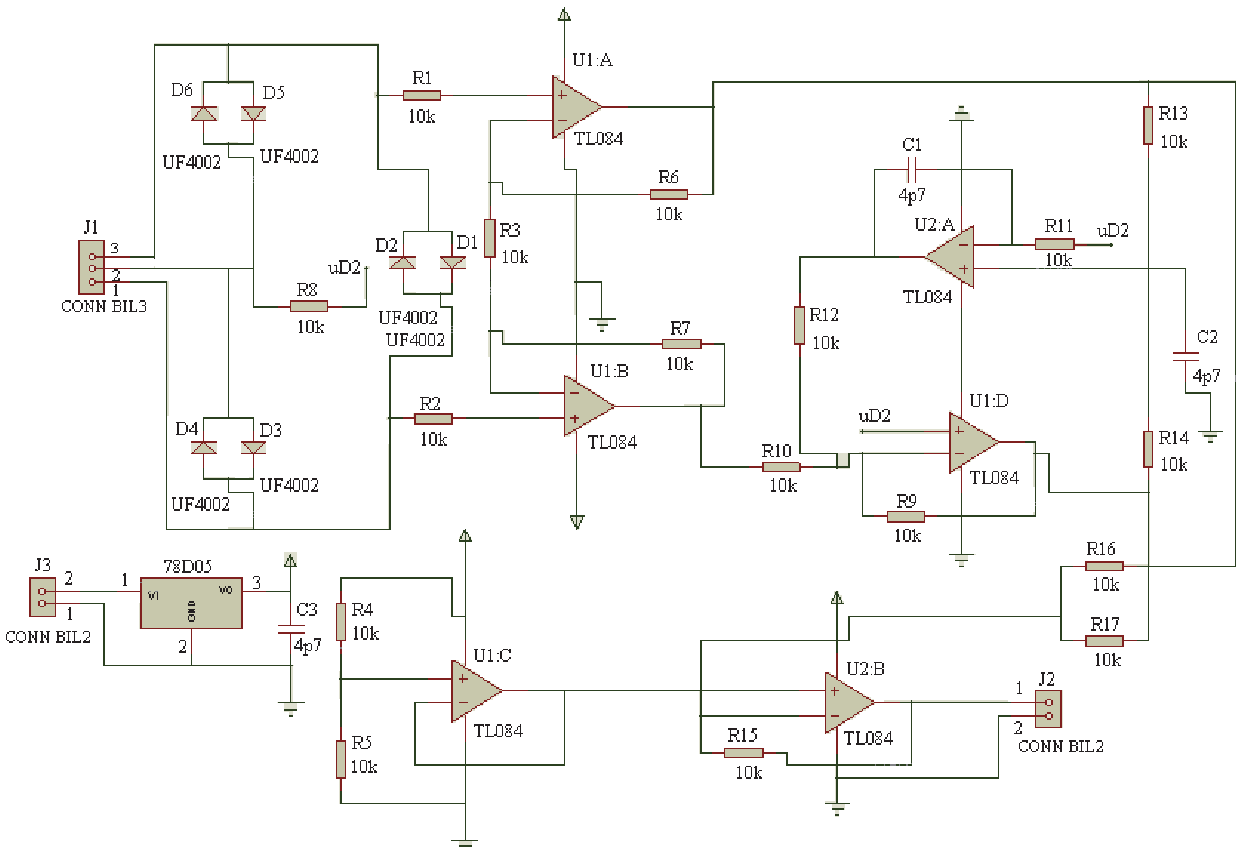


Fig. 5. Final scheme of the ECG circuit

The body potential is firstly recorded at $V_{CC}/2$, connecting the “body electrode” to the left hand. Next, the instrumentation amplifier measures the voltage fluctuations between electrode 1 and 2, amplifies the signal, filtering it and send it to the computer microphone input.
The performances of the proposed circuit, in the case of Varta Superlife9V battery using, are provided in table 1.

The performances of the proposed circuit	Estimated values
Power consumption	max. 15W
Voltage powering	230V AC Univ., 50Hz, 80VA (or 9V DC battery)
Battery life	12 hours
CMRR of amplifier	75-86dB
Circuit bandwidth	0.05-120Hz

Table 1.

The inter-connection of this hardware to a PC or laptop implies some potential hazards for patients and additional noise introducing. Therefore, a main set of algorithms used for the

ECG conditioning with respect to different types of hazards, noise and artifacts in order to extract the basic electrocardiographic signal, is briefly discussed. As the specialty literature notify, the electrical safety should be very careful concerning a home-built circuit connection to something that is running off a significant power source. In principle, one can more safely read out the circuit using a laptop computer that is running off its battery, (Sornmo, 2006). Nevertheless, this leaves the laptop's ground floating, without a good ground connection, with a remarkable amount of noise superposed over the ECG collected signal. Only if the circuit can be connected to a good ground point, then using a battery powered laptop should work well. A solution is to connect the ground of the circuit and the input and output cables to a metal box housing the circuit as carcase, which still fulfils a shield effect. Consequently, the circuit ground will then come from whatever device is looking to the output – either the laptop, PC or oscilloscope. Since these devices are usually powered from the line voltage, the ground from the wall socket often provides a very good ground connection.

Even with the laptop plugged into the mains socket, a significant amount of noise is still found. The best results were obtained by keeping the cables connecting the subject to the circuit close together, thereby reducing the inductive pick-up.

Professionally medical devices are built with significant overvoltage protection, so that line power glitches do not represent a hazard to patients, during the test. To supplementary increase the safety an optically-coupled linear **ISO**lation amplifier can be added to the existing circuit so that the subject is completely isolated from the power supply. In simpler applications, the pair diodes provide limited over-voltage protection.

2.3 Tests and signal processing

The software can process the incoming signal from the ECG output and can offer information about the heart beat, (Rusu, 2008). It is a display software, converting the input analog signal from the microphone muff into a graph. Usually, the program analyses the beat ration, suggesting a normal ECG trace, after the periodicity and beat numbers, or abnormal trace, in terms of P-Q-R-S-T-U waves, (Macfarlane, 2011). The ventricular contraction produces the most clears QRS complex displayed on PC. The P and T waves aren't so consistent in our experiments. Therefore, this mobile ECG system is more recommended for ventricular alerts, especially encountered in the QRS complex deformation.

In absence of a suitable ECG signal generator (e.g. fluke medSim 300B), the circuit was tested directly on a healthy patient, 24 years, as a real ECG signal source. Some output waves recorded with the previous circuit and exposed on PC are presented in fig. 7, 8, 9. Without a 50Hz filter and without a shield additional protection, the dragging signal looks like in fig. 7, due to the antenna behavior of the human body versus the 230V, 50Hz AC signal from laboratory.

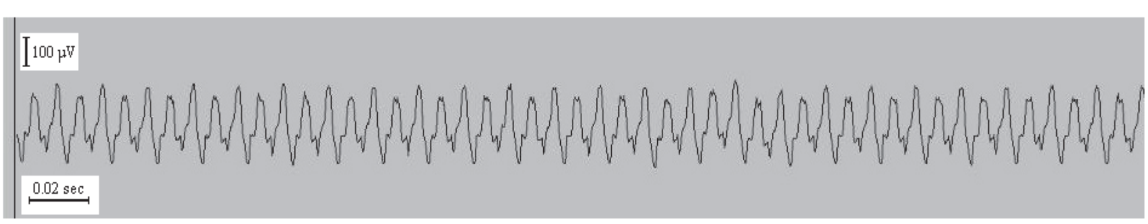


Fig. 7. The output signal without the 50Hz filter

Fig. 8. The output signal with the 50Hz filter

After the 50Hz signal removal, the ECG signal recorded by prior circuit and displayed on PC looks like in fig. 8. Here are obviously the heartbeats, via QRS incipient complex. The output signal from fig. 9 is the best recorded signal, after a low pass filter and choosing different skin sensors with electrolyte solution.

This ECG mobile system has the advantage that it can be connected to a home computer or laptop and it can be used by anyone, not only by the medical staff. The global product is available in fig. 10.

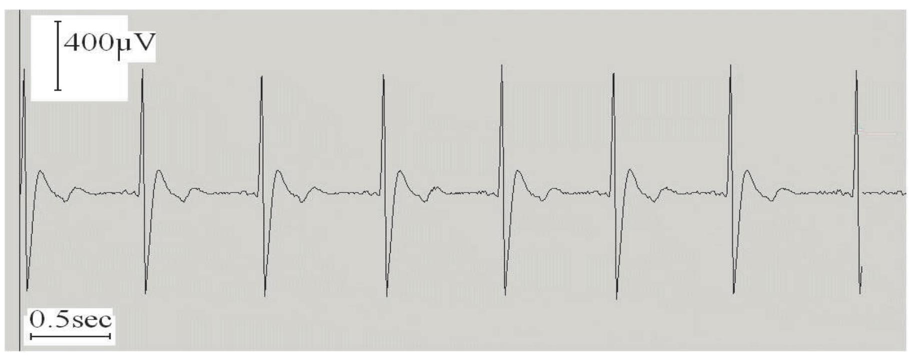


Fig. 9. The final output signal after low pass filter and different skin sensors

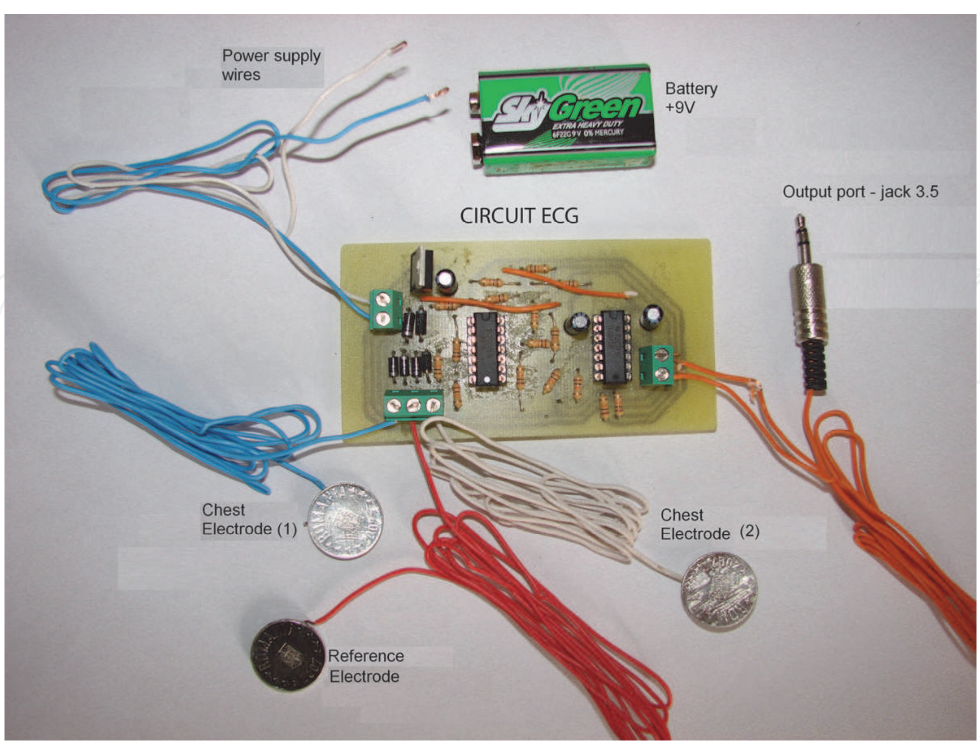


Fig. 10. The circuit, battery, electrodes, connectors and jack output of the circuit

Adding a LCD device to monitor anytime the signal (e.g. at office, walking, running situations), the system can be improved, in order to offer a small, cheap and portable ECG compact device, (Kara, 2006). The power dissipation can be minimized if the circuit is integrated. Some major software improvements could consist in the comparison of the recorded waves within an implemented database, alerting the user if there is a change in the ECG trace and suggesting an initial diagnosis, or normal ECG state.

3. Circuit design for noise rejection in electromyography

In the biomedical engineering domain, the circuits design with high noise immunity for electrophysiology is maintained as a main aim. Besides to the classical ECG, others electro-physiological methods have been developed in order to record the electrical activity of muscles at the skin level. This is the Electro-Myo-Graphy (EMG), (Merletti, 2004). There are two kinds of EMG: surface EMG and intramuscular EMG. A surface electrode may be used to monitor the general picture of the muscle activation, while a few fibers activity can be observed using only an invasive needle, intramuscular applied, (Raez, 2006). The non-invasive EMG method suffers from noise, collected by the surface electrodes.

3.1 Noise in EMG

There are many types of noise to be considered, when EMG is recorded through surface electrodes.

- *Inherent noise in electronics equipment*: It is generated by all electronics equipment and can't be eliminated. It is only reduced by high quality components using. It has a frequency range: 0 – several thousand Hz, (Babarada, 2010b).
- *Ambient noise:* The cause is the electromagnetic radiation, with possible sources: radio transmission, electrical wires, fluorescent lights. It has a dominant frequency of 60Hz and amplitude of 1 – 3 x EMG signal.
- *Motion artifact*: It has two main sources: electrode /skin interface and electrode / cable, having a frequency range of 0 – 20Hz. It is reducible by a proper circuitry and set-up.
- *Inherent instability of signal:* All electronics equipments generate noise and the amplitude is somewhat randomized, being in correlation with the discrete nature of the matter. This noise has a frequency range of 0 – 20Hz and cannot be removed.

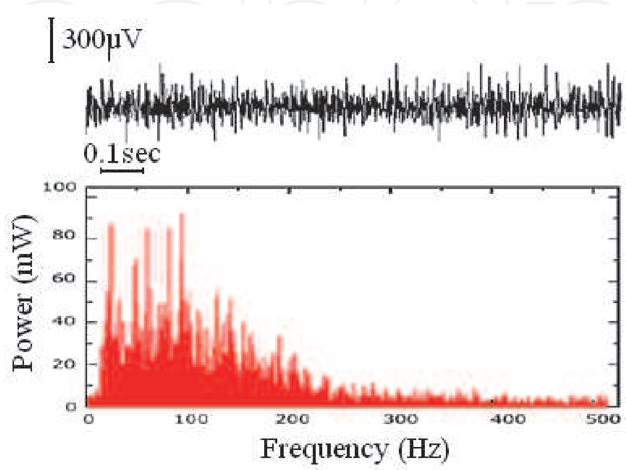


Fig. 11. A noisy signal (black) and power spectrum (red), in typical EMG

The electrical potential measured by non-invasive EMG represents the grouped activity of many muscles fibers firing in varying sequences, at different rates. It has an amplitude range of 0–10 mV peak to peak, prior to amplification and a useable energy for f=0 - 500Hz. The dominant frequency is 50 – 150Hz, fig. 11.
Activity above 500Hz is rather an external electrical artifact and can be hardware eliminated by low-pass filters, with 400-450Hz as cut-off frequency and with a usual roll-off slope of 40dB/dec. Lower frequencies can be contaminated with external noise from the wall power and from biological sources such as ECG and EEG activity - eliminated by the high-pass filters.

3.2 Hardware method in the noise reduction

At the skin level, the entire electrical activity spans a frequency range from several cycles per second through 500Hz. A special attention must be paid to those spectral characteristics of the EMG that dramatically shifts toward lower frequency ranges, when muscles become fatigued. The noise filters must take into account this useful domain.
The first stage of a differential amplifier, frequently used for the EMG acquiring, works also as a high-pass filter, which removes noise caused by the electrode movement on skin. A common-mode feedback is often adopted to reduce the common mode voltage on the subject.
Theoretically, if a biosignal is equally applied on the differential inputs of the operational amplifier, the output should not be affected. In practice, changes in common mode voltage propagate changes to output. The common-mode rejection ratio (CMRR) is the ratio of the common-mode gain to differential-mode gain. The common-mode rejection ratio expressed in decibels, dB, is referred as common-mode rejection (CMR).
In EMG signal acquisition, the amplifier should have the capability to reject the common mode voltages, mainly the power line voltage between subject and ground, which may be thousand times higher then the surface EMG signal. Therefore, a CMR range of 100-120dB is required to limit the equivalent input voltage to a value negligible in respect with EMG, (Bogdan, 2009). Hence, a common mode feedback is often adopted to reduce the common mode voltage. This technique consists in detecting and re-applying of the common mode voltage to the subject, with opposite phase.

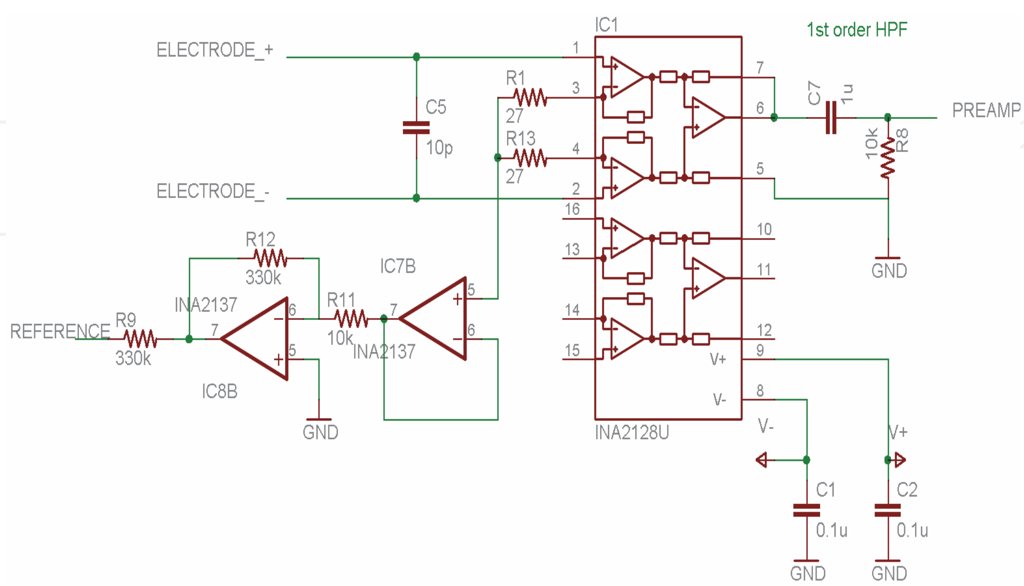
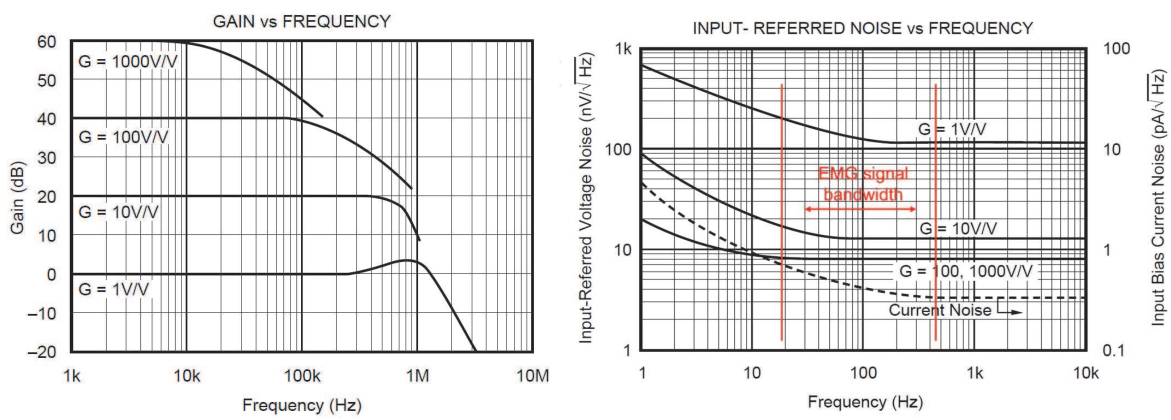


Fig. 12. The proposed active filter for the EMG recording

Figure 12 proposes a circuit based on an amplifier/high-pass filter, with INA2128, INA2137 as instrumentation amplifiers that uses the negative feedback. Due to the INA2128 current-feedback topology, the gate voltage is roughly 0.7V, less than the common-mode input voltage, (Texas Instruments, 2007). This DC offset into the guard potential is satisfactory for many guarding applications.



(a) (b)

Fig. 13. (a) Gain versus Frequency for the prior filter; (b) the input-referred noise versus frequency

The amplitude of the acquired EMG signals ranges from 10μV to 1000μV. These signals need amplification from 60 to 100dB, so that 1V signal is available for the amplification sub-system. This technique also helps to the EMG signal quality and keeps the distortions as minimal as possible. INA2128 has an adjustable gain, using a single external resistor, R:

$$A_v = \left(1 + \frac{50k\Omega}{2R}\right) \tag{4}$$

where R = R_1 = $R_{13,}$ from fig. 12, are expressed in kΩ. Despite to the quiescent current, the Gain - Frequency curve presents wide bandwidth, even at high gain. This is due to its current-feedback topology, fig. 13.a. The output-referred noise does not allow a fair comparison of the circuits performances because it depends on the gain between the input refereed noise and the input signal - both multiplied by the gain as they are processed by circuit. Thus, the input-referred noise indicates how much the input signal is corrupted by the circuit's noise, fig. 13.b.

3.3 Software processing of EMG signal

Another way to remove the noise from an EMG signal is by software processing of the acquired signal**.** Some methods that proved their efficiency are:

- *Artificial intelligence*: Some artificial intelligence techniques based on neural networks can be used for the EMG signal processing. This kind of technique is very useful for real-time application like EMG signal recording and analysis.
- *Autoregressive model*: an autoregressive moving average model from neural firing data from motor cortical decoding was studied for the hand motion decoding, (Fisher, 2006).

The autoregressive (AR) time series model can be used in EMG study, too. A surface electrode picks up the EMG activity from all the active muscles in its vicinity, while the intramuscular EMG is highly sensitive, with only minimal crosstalk from adjacent muscles. The EMG signal is represented as an AR model with the delayed intramuscular EMG as input. An artificial neural network combined with an autoregressive model was used to drive the biceps of an arm prosthesis, (Fisher, 2006). The Ag electrodes are placed on biceps at 3cm distance from each other and behind the triceps. The EMG signal obtained from the electrodes is amplified and passed through a low-pass filter to be sent to the level determining circuit.

- *Wavelet analysis*: The wavelet transform (WT) represents a very suitable method for the classification of EMG signals because it has the advantage of being linear, yielding a multi-resolution representation and not being affected by cross terms, (Jahankhani, 2008).

Figure 14 shows the result of wavelet analysis in the EMG processing.

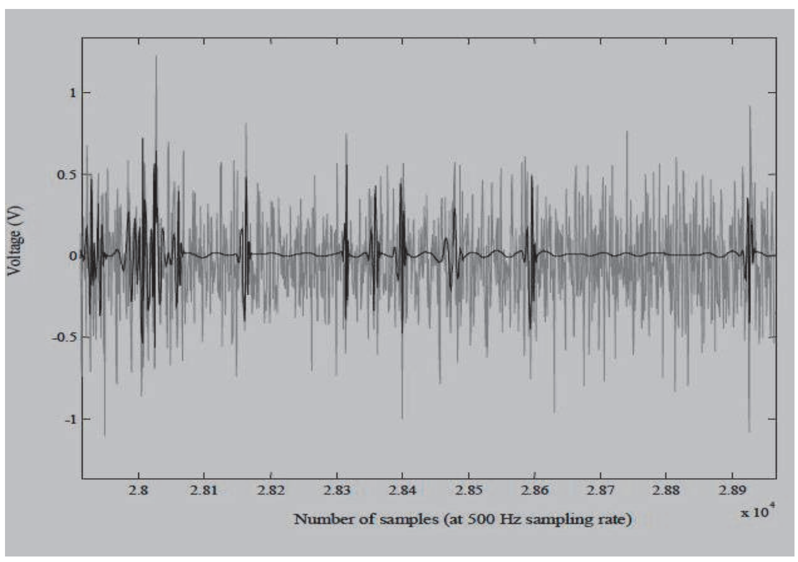


Fig. 14. Comparison of the initial noisy signal (grey) and the denoised signal (black)

4. Toward new electro-grams

In the last years the biology has advanced in the natural pacemakers researching. Although all of the heart's cells possess the ability to generate the electrical impulses or action potentials, only a specialized portion of the heart, called the sinoatrial node, is responsible for the whole heart's beat. The cells that create these rhythmical impulses are called pacemaker cells. Besides to the cord rhythm and brain periodical activity, others and others organs were discovered with a cyclic activity. For instance, the digestive muscles, without any alimentary stimulus, have periodic contractions, from 0.3 up to 12 cycles / minute. In this case, the Interstitial Cajal Cells (ICC), distributed along the gastrointestinal tract, fulfill the pacemaker role, (Sanders & Ward, 2006). Many types of smooth muscle tissues have recently been shown to contain ICC, but with few exceptions, the functions of these cells are a research subject, being still unknown. In this way, the electrophysiological measurements are possible, recording the electrical gastric activity within the electrogastrography, EGG, (Květina, 2010).

Another electrophysiological test is the electroretinography, ERG, relatively recent standardized, (Marmor, 1999), but still a rare clinical test. A related electrophysiological

eyes test measures the resting potential of retina, by electro-oculography, EOG, (Brown, 2006). Unlike the electroretinography, the EOG does not represent the response to individual visual stimuli. Also, an electrohepatography, EHG, was possible in a canine model, revealing waves with identical frequency and amplitude from the 3 electrodes, which were sutured to the capsule on the anterior surface of the canine liver. The mean frequency of the waves was 10.6 ± 1.8 cycles/sec and the amplitude 63.7 ± 11.6 μV. The waves were reproducible when the test was repeated in the same animal. Hepatoarrhythmic electric activity was registered in liver insult of the canine model or in liver diseases, (Shafik, 2000).
There are some organs, whose pacemakers were proved, but are not known yet. For instance, the pancreas presents a cyclic insulino-secretion, with or without meals, which prooves the existance of some cells with natural pacemaker role, (Ravariu, 2011). Probably, an electrophysiological activity coud be detected, in the next future, in a same manner as for liver or brain. So, the way toward new electrophysiological methods will be opened in the next years.

4.1 The cellular origin of the electrophysiological signals

The excitable cells, like neurons, myocytes or some secretory cells in glands, like beta cells alpha cells, maintain a negative potential difference across the cellular membrane, due to a gradient of the ionic charges. All these phenomena are caused by specific changes in membrane permeability for potasium, sodium, calcium and chloride, which produces concerted changes in the functional activity of different ion channels, ionic pumps, exchangers and protein transporters. Conventionally, the membrane resting potential, RP, can be defined as the value of the transmembranar voltage from i.c. to e.c. environment in these cells. Any kind of cell posses its own resting potential value, (e.g. RP = -70mV for some neurons, RP = -60mV for beta cells), (Fox et al, 2006).
An action potential, AP, is a self-regenerating wave of electrochemical activity that allows excitable cells to carry a signal over a distance. This feature of the excitable cells is to provide an output reply to an input stimulus. Among the neuronal cells, the stimulus consists in neurotransmitters and the reply is propagating as the action potential, also named nervous impulse. For small incoming stimulus, the potassium current prevails thru the ionic channels and the membranar voltage turns back to its resting value, typically −70mV, (Purves, 2008). For stronger stimulus that overcomes a critical threshold value, typically 15mV, higher than the resting value, the sodium channels are opening. This produces a positive feedback from the sodium current that activates others sodium channels. Thus, the cell fires, producing an action potential, (e.g. AP = +30mV for neurons or AP = -30mV for beta cells).
In the case of muscular activity, the electrical stimulus of myocytes is provided by a motor neuron and electrochemically transmitted by acetylcholine neurotransmitter. For instance, a motor unit is defined as one motor neuron and all of the muscle fibers it innervates. The area where the nerve contacts the muscle is called the neuromuscular junction. After the action stimulus is transmitted across the neuromuscular junction, an action potential is elicited in all of the innervated muscle fibers of that particular motor unit. The sum of all these electrical activities is known as a motor unit action potential (MUAP), (Raez et al, 2006). This electrophysiological activity from multiple motor units is the typical signal evaluated during an EMG.

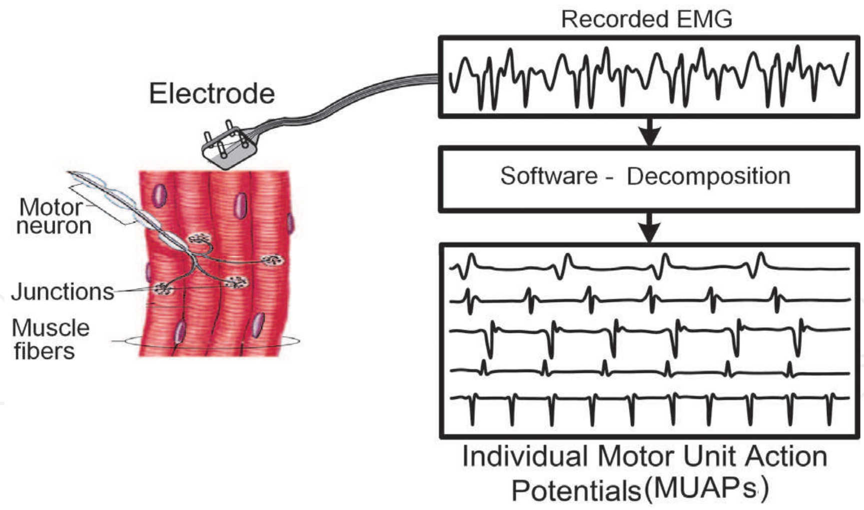


Fig. 15. EMG signal and the decomposition of MUAPs

In figure 15 can be observed in principle the EMG recording signal, the neuromuscular junction and the shapes of the motor unit action potential, after a decomposition of the physical signal.

4.2 A weak signal from non-invasive EGG

The interstitial Cajal cells serve as electrical pacemakers and generate spontaneous electrical slow waves in the gastrointestinal tract. Electrical slow waves spread from ICC to smooth muscle cells and the resulting depolarization initiates the calcium ion entry and contraction. The Cajal cells trigger the gut contractions with different frequencies: 3 per minute for stomach, 12 per minute for duodenum, 10 per minute for ileum, 3 per hour for colon, ensuring the bowel peristalsis. Therefore, the electrical activity recording of the bowels is possible, by electrogastrography. The classical method is invasive, with needle inserted in the stomach during the endoscopy or by surgical act. Nowadays methods try to use a non-invasive recording, with a pair of bipolar electrodes configuration.
In a first experiment, the six electrodes of a standard ECG apparatus, were placed onto the gastric zone, since to observe an electrogastrography trace, fig. 16.a. Unfortunately, the collected signal preserve the heart beat cadence, due to the internal set-up of the dedicated cardiac apparatus, fig. 16.b. In this way, was proved that the cardiac signal is strong enough to cover all surrounding organs. Other experiments are necessary.

(a) (b) (c)

Fig. 16. The electrodes places and the recorded EGG

The prior electrophysiological equipment, designated for the ECG mobile platform, was re-allocated toward the gastric signal detection, by skin electrodes. In this scope, three plat electrodes were placed on skin, on the epigastric zone. The filter resistances were adjusted in order to collect only 1Hz-0.05Hz frequencies, as useful domain for an EGG test. The subject was monitored, after 3 hours post-prandial. Figure 16.c presents the acquired signal. It appears rather as an electromyography signal, probably due to the strong muscular abdominal wall. The interaction among different organs and tissues signals, at skin level, represents the main disadvantage of the remote electrophysiological techniques.

4.3 The remote electrophysiology concept

This paragraph intends to promote a novel term for the medical techniques, in order to be more precise. There are well-known and well-accepted the investigations classifications, after body space or intrusion, as in vivo / in vitro and also intrusive / non-invasive methods. From our experimental tests in electrophysiology, a distinct concept arises in order to proper characterize a measurement. For instance, an electrogastrography is classical recorded by invasive needles. Obviously, this is a strong invasive method, applied in vivo. A less invasive technique is to introduce some plate electrodes, by endoscope, till they contact the internal stomach wall. This last EGG is in vivo recorded, but is almost non-invasive, avoiding the tissue penetration. However, the electrodes touch the gastric mucosa and a special attention has to be paid to the instruments sterilization. It doesn't enter in touch with the blood, as for the needles case, but the danger of diseases transmission still exists. Therefore, both methods are named "*in-touch*" methods.

If the electrogastrography EGG test occurs with some surface electrodes, at skin level, the gastric signal is remotely registered. This is a non-invasive technique, applied in vivo, at a considerable distance from the source electrical signal emitted by the stomach pacemakers. These "*remote*" electrophysiological measurements are crucial in some cases, when any invasive method is forbidden. For instance the liver is inaccessible without a minimum surgical act. Also, for pancreas or brain any invasive or even "in-touch" method, can irreversible damage the tissue, (C. Ravariu, Tirgoviste, 2009).

There are many other medical techniques that can collect signs and tests, either by an immediate contact with the investigated organ, either by remote recording. As much as more biological layers and tissues are interposing between the medical tool terminal and the target organ, the test move from "*in-touch*" to "*remote*". In the last years, due to the sterilizing accidents, non-invasive methods were preferred. Low invasive electrodes with micro-needles, are still dangerous, being in contact with blood capillary, (Gowrishankar et al, 2008). The "in-touch" methods, with surface electrodes in immediate contact with teguments or mucosa suffer form facile microbial transmission. Therefore a more accurate distinction must be made among: invasive, low invasive, in-touch and remote investigation methods.

5. Conclusions

One of the main contributions of this chapter is the global application idea for an ECG mobile platform and its practical implementation. An integrated circuit - TL 084 CN – was used, which posses four operational amplifiers. The advantage of the proposed circuit is that it is powered from only one 9V battery, the 0 level is at $V_{CC}/2$. The $V_{CC}/2$ level is given by one simple resistor divider, followed by a buffer.

The amplified signal is introduced in a PC, by the microphone muff. The incoming signal can be software processed and shown as ECG trace on the computer display. This electronic

format of the ECG data avoids the additional expensive mechanics tracer for customer and can be easily transferred to a medical center, via the telemedicine methods.
Secondly, the chapter discussed some hardware and software methods to reduce the noise during the Electromyography. The hardware technique consists in detecting and re-applying of the common mode voltage to the subject with opposite phase via the INA2128 current-feedback topology. The main software contribution is by wavelet transform (WT) that represents a very suitable method for the classification of EMG signals due to its linearity advantage, yielding a multi-resolution representation.
Finally, an incursion into nowadays electrophysiology is exposed, in order to estimate the new challenges. The electrogastrography EGG was intensively investigated in the last ten years in the world wide, but it is a novelty in Europe. This study reveals the interferences among the EGG, ECG and EMG signals, at skin level. The strongest is the cardiac signal and the weakest is the gastric signal. But the low level of the non-invasive EGG collected signal is related to many biological layers and frontiers between the target organ and the skin electrodes. In this way, a novel concept was introduced: remote electrophysiological tests versus in-touch tests. Sometimes, only remote methods can be accepted, in respect with the tissue particularities. The term of "remote medicine" ensure a larger spectrum, taking into account the remote diagnosis centers, coupled with telemedicine. Therefore, the term of remote medicine find a technical sense in electrophysiology, but also a social dimension in the modern medicine.

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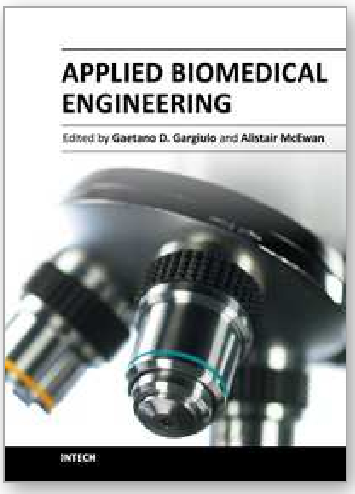

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