

**A.H. HAKOBYAN, L.E. HOVHANNISYAN, A.S. ALAVERDYAN,  
A.H. YARIJANYAN NAMAGERDI, S.V. MATINYAN, M.R. MOVSISYAN,  
K.B. YENKOYAN, S.T. MURADYAN**

**DESIGN OF AN ELECTRICAL CIRCUIT FOR LOCAL FIELD  
POTENTIAL CONDITIONING**

The latest achievements in the fields of machine learning and artificial neural networks have made the recording of Local Filed Potentials (LFP) a more valuable method for the study of the brain activity. Along with the improvement of analysis of the gained data, the modern approaches in signal amplification schemes brought progress in this method. We have designed and created an electrical circuit on the basis of the NI ELVIS II platform, for recording of LFP. The design and results of testing the created circuit are presented in the current paper.

**Keywords:** Local Filed Potentials (LFP), LFP recording circuit, NI ELVIS II platform, LFP circuit testing

**Introduction.** The recording of electrical activity of the brain is an irreplaceable method for studying the behavior of neural populations and mathematical or physical patterns underlying this behavior. Among various techniques, the extracellular recording is widely used for investigation of network activity. LFP is a compound signal, which is the result of various electrical currents generated in the extracellular space. Mainly LFP points out the synchronized synaptic activity of a large group of neurons [1]. The advantage of LFP recording is the high spatial resolution and relative uniform conductivity of the selected area. An additional reason for interest in LFPs is that they provide a stable signal for a longer period than multiunit spiking activity, and therefore, are useful for long-term chronic experiments and for clinical applications such as Brain Machine Interfaces (BMI) [2]. However, as LFP captures a multitude of neural processes, the extraction of essential features is among the main problems of Computational Neuroscience. The LFP can be recorded by placing electrodes in a brain tissue. The impedance of the electrodes and considerably the quality of the recording depends on the material, geometry and referencing of electrodes [3].

The electrical activity of a brain can be a signature of cognitive impairment [4], persistent pain [5] physiomarker of the symptomatic state in Parkinson's disease [6], etc.

**Methodology.** We have used the NI ELVIS II platform as a base for our system. NI ELVIS II is a data acquisition system, which has 8 differential analog inputs with 16 bits resolution and 1 MS/s speed for signal recording [7]. It also has 2 analog outputs with 12 bits resolution and 2 MS/s update rate for signal generation.

The electrical scheme of the designed circuit for LFP conditioning is shown in Fig.1.

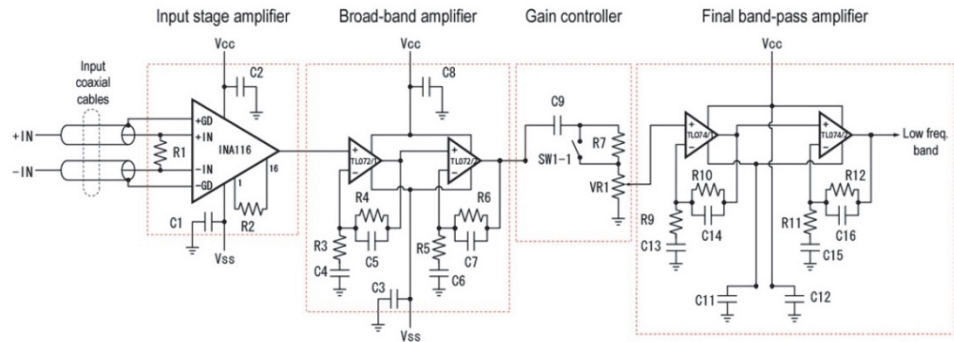


Fig. 1. The electrical scheme of the LFP conditioning circuit

This electrical circuit includes steps of 1) preamplification 2) amplification 3) gain control and 4) filtering. We have chosen the parameters of the scheme so that it amplifies the signals with frequencies between 10 to 1000 Hz about 1000 times.

**Measurements and Results.** To evaluate the gain-frequency characteristics of our circuit, we have conducted Bode analysis with an input signal with 0.7 mV amplitude and a frequency that varies from 1 Hz to 200 kHz. The results of these measurements are presented in Fig. 2.

In Fig. 2, on the vertical axis, the amplification factor (in dB) and on the horizontal axis, the frequency of the input signal (in Hz) are shown.

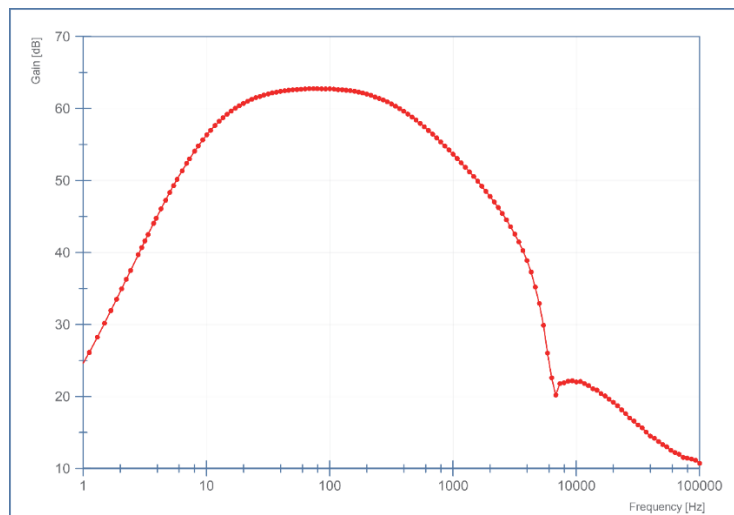


Fig. 2. Gain-frequency characteristics of the LFP conditioning circuit

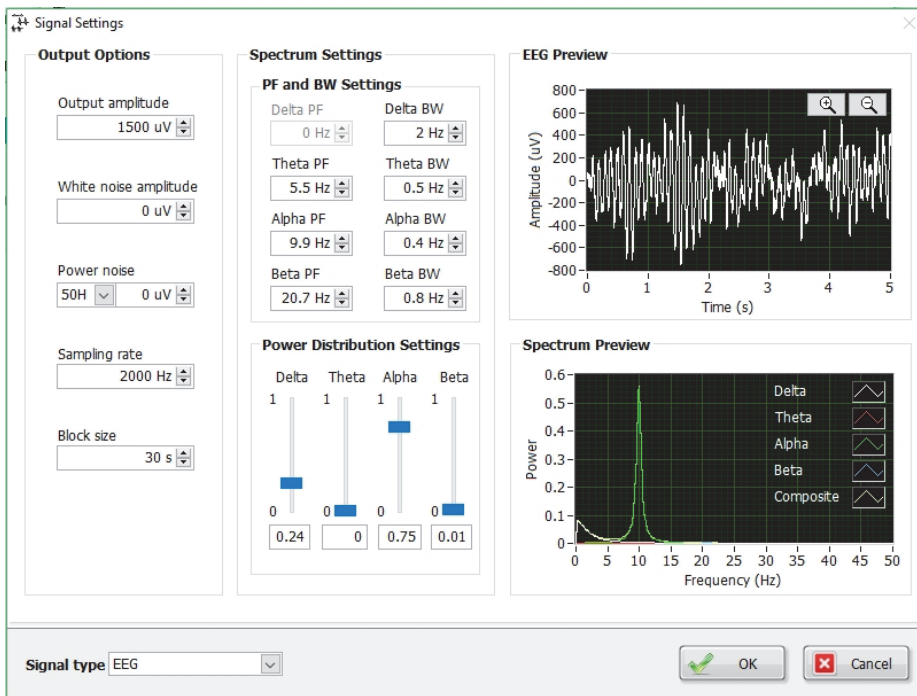
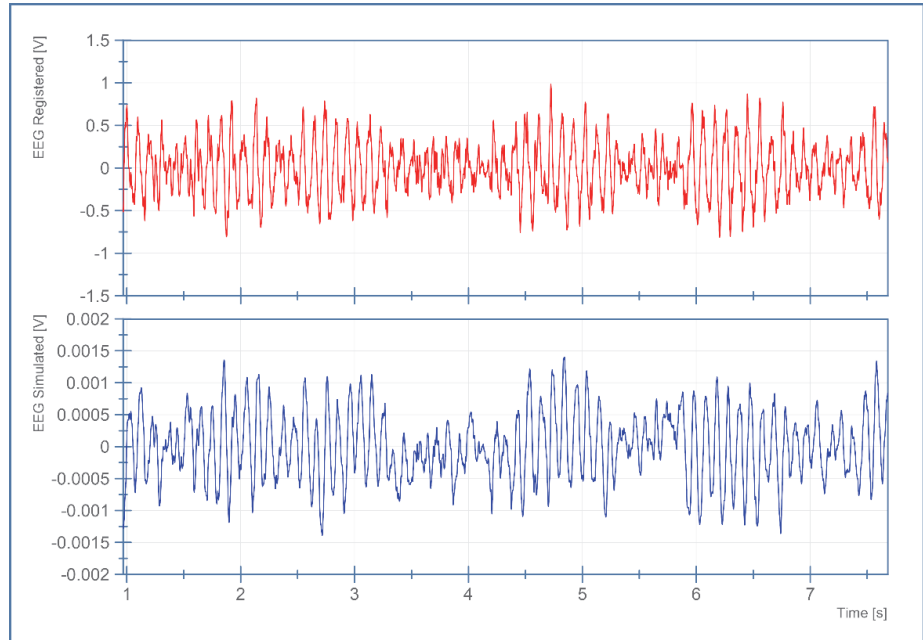


Fig. 3. The parameters of the generated EEG signal in NI Biomedical Workbench software

To test the signal conditioning capabilities of our circuit, we have generated EEG signals (electroencephalography) on the analog output channel of the NI ELVIS II. To form the EEG signal, we have used the NI Biomedical Workbench software. The parameters of the generated EEG signal are shown in Fig.3.

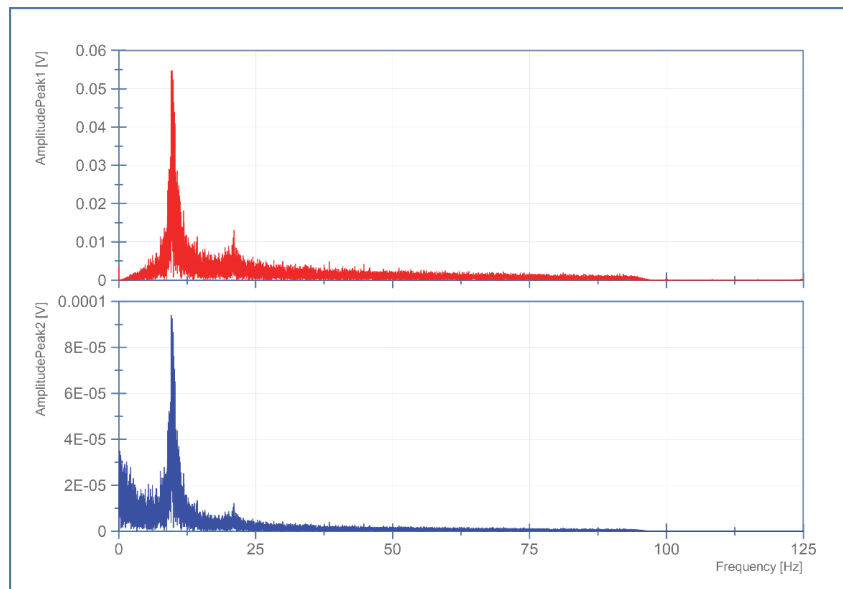
As it is can be seen from Fig.3, the generated EEG signal has 1.5 mV amplitude and 3 components: “Alpha” – 9,9 Hz, “Beta” – 20,7 Hz, “Delta” – 0÷2 Hz. We have put this signal as an input signal of our signal conditioning circuit.

The results of simultaneous recording of the input and output signals of the LFP signal conditioning circuit are presented in Fig.4.



*Fig. 4. The input (bottom one) and output (upper one) signals of the LFP signal conditioning circuit*

In Fig.5, we have brought the Fast Fourier Transform (FFT) spectrums of our input and output signals.



*Fig. 5. The FFT spectrums of input (bottom one) and output (upper one) signals*

The bottom curve in Fig.5 shows the 3 components of the generated EEG signal: “Alpha” – 9,9 Hz, “Beta” – 20,7 Hz, “Delta” – 0÷2 Hz. The upper curve in Fig.5, which is the FFT spectrum of the output signal, contains only 2 components: “Alpha” – 9,9 Hz, “Beta” – 20,7 Hz. The third low-frequency component is eliminated because of the design of the signal conditioning circuit. Our circuit amplifies the signals in the frequency range from 10 Hz to 1000 Hz (Fig.2).

**Conclusion.** We have designed and created an electrical circuit for LFP signal conditioning on the basis of the NI ELVIS II platform. The created circuit amplifies signals in the frequency range from 10 Hz to 1000 Hz by the factor of 1000. These parameters make the circuit a suitable tool for LFP signal conditioning. In our further studies, we are going to use this circuit for registration of LFP signals from the brains of mice.

#### REFERENCES

1. **György Buzsáki Costas, A. Anastassiou, Christof Koch.** The origin of extracellular fields and currents — EEG, ECoG, LFP and spikes // Nature Reviews Neuroscience.- June 2012.-V.13. -P. 407-420 | doi:10.1038/nrn3241
2. **Alberto Mazzoni, Nickos K. Logothetis, Stefano Panzeri.** The information content of Local Field Potentials: experiments and models // <https://arxiv.org/ftp/arxiv/papers/1206/1206.0560.pdf>
3. **Andrew Sharot.** Local Field Potential, Methods of Recording // Encyclopedia of Computational Neuroscience.-Publisher Springer, New York.-doi10.1007/978-1-4614-7320-6\_723-1.
4. **Colleen Dockstader, Frank Wang, Eric Bouffet, and Donald J. Mabbott.** Gamma Deficits as a Neural Signature of Cognitive Impairment in Children Treated for Brain Tumors // The Journal of Neuroscience.-25 June 2014.-V.34(26). -P. 8813-8824 | doi: 10.1523/JNEUROSCI.5220-13.2014
5. **Carl Y. Saab.** Pain-related changes in the brain: diagnostic and therapeutic potentials // Trends in Neurosciences.-2012.-V. 35(10). -P. 629-637.
6. **Rahul Gupta, Dwight Nelson, Spatio-Temporal.** Characterization of beta and Higher Frequencies in Intra-Operative STN LFPs from PD Patients // Neurology.- 2013.-V. 80(7) Supplement. -P. 178.
7. <http://www.ni.com/datasheet/pdf/en/ds-394>

**Ա.Հ. ՀԱԿՈՐՅԱՆ, Լ.Է. ՀՈՎՀԱՆՆԻՍՅԱՆ, Ա.Ս. ԱԼԱՎԵՐԴՅԱՆ,  
Ա.Հ. ՅԵՐԻՋԱՆՅԱՆ ՆԱՄԱԳԵՐԴԻ, Ս. Վ. ՄԱՏԻՆՅԱՆ, Մ. Ռ. ՄՈՎՍԻՍՅԱՆ,  
Կ.Բ. ԵՆԿՈՅԱՆ, Ս.Տ. ՄՈՒՐԱԴՅԱՆ**

**ՏԵՂԱՅԻՆ ԴԱՇՏԵՐԻ ՊՈՏԵՆՑԻԱԼԻ ԳՐԱՆՑՄԱՆ ԷԼԵԿՏՐԱԿԱՆ ՇՂԹԱՅԻ  
ՄՇԱԿՈՒՄԸ**

Մերենայական ուսուցման և արհեստական նեյրոնային ցանցերի հետազոտությունների վերջին ձեռքբերումներով տեղային դաշտերի պոտենցիալների (ՏԴՊ) գրանցումը դարձել է ուղեղի ակտիվության ուսումնասիրման ավելի արժեքավոր մեթոդ: Գրանցված տվյալների մշակման, ինչպես նաև ազդանշանների ուժեղացման սխեմաների նախագծման վերաբերյալ նոր մոտեցումները նպաստում են այս մեթոդի զարգացմանը: Ու ELVIS II հարթակի հիման վրա նախագծվել և ստեղծվել է էլեկտրական շղթա ՏԴՊ գրանցման համար: Ներկայացվել են ստեղծված շղթայի կառուցվածքը և թեստավորման արդյունքները:

**Առանցքային բաներ.** տեղային դաշտերի պոտենցիալ (ՏԴՊ), ՏԴՊ գրանցման շղթա, Ու ELVIS II հարթակ, ՏԴՊ շղթայի թեստավորում:

**Ա.Ա. АКОПЯН, Л.Э. ОГАННИСЯН, А.С. АЛАВЕРДЯН,  
А.Г. ЯРИДЖАНЫН НАМАГЕРДИ, С.В. МАТИНЯН, М.Р. МОВСИСЯН,  
К.Б. ЕНКОЯН, С.Т. МУРАДЯН**

**РАЗРАБОТКА ЭЛЕКТРИЧЕСКОЙ СХЕМЫ ДЛЯ РЕГИСТРАЦИИ  
ПОТЕНЦИАЛОВ ЛОКАЛЬНЫХ ПОЛЕЙ**

Последние достижения в машинном обучении и искусственных нейронных сетях сделали регистрацию потенциалов локальных полей (ПЛП) более ценным методом для изучения мозговой активности. Современные подходы к обработке зарегистрированных данных и проектированию схем для усиления сигналов способствуют развитию данного метода. На базе платформы NI ELVIS II спроектирована и создана электрическая схема для регистрации ПЛП. Представлены конструкция и результаты тестирования созданной схемы.

**Ключевые слова:** потенциалы локальных полей (ПЛП), схема регистрации ПЛП, платформа NI ELVIS II, тестирование схемы регистрации ПЛП.