2019 4th International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE 2019)

Yogyakarta, Indonesia
20 – 21 November 2019

IEEE Catalog Number: CFP19G48-POD
ISBN: 978-1-7281-5119-9

IEEE Catalog Number:	CFP19G48-POD
ISBN (Print-On-Demand):	978-1-7281-5119-9
ISBN (Online):	978-1-7281-5118-2

Additional Copies of This Publication Are Available From:

Curran Associates, Inc
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: (845) 758-0400
Fax: (845) 758-2633
E-mail: curran@proceedings.com
Web: www.proceedings.com

CURRAN ASSOCIATES INC.
proceedings.com

2019 4th International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE)

Parallel Session 1-A

Parallel Session 1-B

Parallel Session 1-C

Parallel Session 2-B

Parallel Session 2-C

Parallel Session 2-D

Parallel Session 2-E

Parallel Session 3-A

Parallel Session 3-B

Parallel Session 3-C

Parallel Session 3-D

Parallel Session 3-E

2019 4th International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE) took place 20-21 November 2019 in Yogyakarta, Indonesia.

IEEE catalog number:	CFP19G48-ART
ISBN:	978-1-7281-5118-2

WELCOME MESSAGE FROM ICITISEE 2019 GENERAL CHAIR

Good morning, distinguished guests, Keynote Speakers Prof. Naoyuki Kubota, Ph.D. and Dr. Eng. Igi Ardiyanto, S.T, M.Eng, Head of Higher Education Service Institute Prof.Dr. Didi Achjari, S.E., M.Com., Akt., IEEE Indonesia representative, Dr. Kurnianingsih, Leader and member of Department of Electrical Engineering and Information Technology Universitas Gadjah Mada, Rector and all leader of Universitas AMIKOM Purwokerto, Rector and all leader of Universitas AMIKOM Yogyakarta, Speakers and all of the participants. Allow me to say a warm welcome to all of you, to The 4th International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE-2019).

This conference is jointly organised by the Department of Electrical Engineering and Information Technology, Universitas Gadjah Mada, Universitas Amikom Yogyakarta, and Universitas AMIKOM Purwokerto, Indonesia.

ICITISEE-2019 provides a unique opportunity for all of the academia, professionals and researchers to share their research result about the role of data science in future technology.

I am very pleased to see so many colleagues, professors and friends from many countries gather together in one place! There are 236 papers has been submitted to our conference system, and after going through the review process, we have 104 papers declared as accepted and ready to be presented at today's conference. These papers were written by authors who come from many countries, such as Indonesia, Taiwan, Malaysia, India, Japan, UK, Philliphina and Australia. I would love to say congratulations to all of you!

The ICITISEE-2019 Committee has been working extremely hard for about a half year to get this conference well prepared for today as we all may see. As a result, before this session, we have done parallel sessions early in this morning to allow 30 authors presenting their papers.

In this session, we will have speeches from two keynote speakers:

Dr. Eng. Igi Ardiyanto, S.T, M.Eng, Researcher and academic staff at Departement of Electrical Engineering and Information Technology, Universitas Gadjah Mada, Indonesia will share about Explainable Artificial Intelligence: Current State and Future. Thank you for coming.

Prof. Naoyuki Kubota, Ph.D. from the Research Center for Community-centric Systems, Research Core on Service Robot Incubation Hub, Faculty of Systems Design, Tokyo Metropolitan University, Japan. He will enlight us about Intelligent Technology for Social Robotics. Thank you for coming.

After this session, there are two parallel sessions to allow more than 70 authors to present their papers and have a discussion with all of the participants.

As our appreciation for the authors, we will choose the best paper in the conference and will be announced at the closing session this afternoon.

We hope this conference will enlight us with each other and giving us inspiration and motivation to give a real contribution to the community. Your strong support and active participation have made the ICITISEE-2019 as a valuable and useful international conference.

We know that holding this conference may seem far from the perfectness. For that, we apologise for things that maybe not pleasing or uncomfortable in your heart.

Thank you and enjoy the conference. Yogyakarta, 20th November 2019

Dr. Kusrini, M.Kom General Chair of 4th ICITISEE 2019

Organizing Committee

General Chair

Kusrini Kusrini (AMIKOM Yogyakarta University, Indonesia)

Publication Chair

Sumarni Adi (Universitas AMIKOM Yogyakarta, Indonesia)
Akhmad Dahlan (Universitas Amikom Yogyakarta, Indonesia)

Secretary

Yoga Pristyanto (Universitas Amikom Yogyakarta, Indonesia)
Nila Puspitasari (Universitas AMIKOM Yogyakarta, Indonesia)

Treasurer

Sumarni Adi (Universitas AMIKOM Yogyakarta, Indonesia)

Chair of Technical Program Committee

Emha Taufiq Luthfi (Universitas AMIKOM Yogyakarta, Indonesia)
Lesnanto Multa Putranto (UGM, Indonesia)
Arief Setyanto (Universitas AMIKOM Yogyakarta, Indonesia)
Andi Sunyoto (Universitas AMIKOM Yogyakarta, Indonesia)
Ferry Wahyu Wibowo (Universitas Amikom Yogyakarta, Indonesia)

Institutional Sign In

Electroencephalograph Recording with Ten-Twenty Electrode System Based on Arduino Mega 2560

Publisher: IEEE Cite This PDF

Titis Bagus Kurnianadi ; Florentinus Budi Setiawan **All Authors**

Abstract: Improved Technology until now started to help many aspects of human works, including medical facilities. One of them is Electroencephalography (EEG) which records electri... **View more**

Metadata

Abstract:
Improved Technology until now started to help many aspects of human works, including medical facilities. One of them is Electroencephalography (EEG) which records electrical activities of the brain. This technology is used to diagnose any brain disease that makes an abnormality at EEG signal recording. EEG usually has non-invasive methods, where electrodes placed on the scalp that easy and reusable. This technology itself has been started in 1924 by Hans Berger. This paper discusses the basic construction of EEG, focused on simulation, device construction, and results from devices. It will further mention how Arduino Mega 2560 record analog signals, circuit diagrams that will be used, and final results that showed and processed on SCILAB application. The final result would use Ten-Twenty Electrode System which can be compared with any result from any different recording and be displayed in SCILAB with graph form that has been filtered with Fast Fourier Transform (FFT) results.

Published in: 2019 4th International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE)

Date of Conference: 20-21 November 2019

Date Added to IEEE *Xplore*: 02 April 2020

ISBN Information:

INSPEC Accession Number: 19550872

DOI: 10.1109/ICITISEE48480.2019.9003819

Publisher: IEEE

Conference Location: Yogyakarta, Indonesia

Contents

I. Introduction

Technologies now have roles in many fields to support mankind, including in the medical field. Medical technologies applicating principles and design for medical needs. One of them is Electroencephalography (EEG) that recording brainwave signals activities. [1] EEG technology is used in medical fields to diagnose any brain disease that causes abnormalities at EEG recording. [2], [3] EEG method is commonly used at medical and research purposes since EEG using non-invasive methods and accessible, where electrodes are placed at the scalp. [4] The main reason for EEG usage is to obtain and observe Event-Related Potentials (ERP) that can be achieved from the averages of EEG signals in a specific stimulus at a specific time. [5]

Authors

Figures

References

Keywords

Metrics

Electroencephalograph Recording with Ten-Twenty Electrode System Based on Arduino Mega 2560

Titis Bagus Kurnianadi
Department of Electrical Engineering
Soegijapranata Catholic University
Semarang, Indonesia
15f10002@student.unika.ac.id

Florentinus Budi Setiawan
Department of Electrical Engineering
Soegijapranata Catholic University
Semarang, Indonesia
fbudis70@gmail.com

***Abstract*— Improved Technology until now started to help many aspects of human works, including medical facilities. One of them is Electroencephalography (EEG) which records electrical activities of the brain. This technology is used to diagnose any brain disease that makes an abnormality at EEG signal recording. EEG usually has non-invasive methods, where electrodes placed on the scalp that easy and reusable. This technology itself has been started in 1924 by Hans Berger. This paper discusses the basic construction of EEG, focused on simulation, device construction, and results from devices. It will further mention how Arduino Mega 2560 record analog signals, circuit diagrams that will be used, and final results that showed and processed on SCILAB application. The final result would use Ten-Twenty Electrode System which can be compared with any result from any different recording and be displayed in SCILAB with graph form that has been filtered with Fast Fourier Transform (FFT) results.**

Keywords*— *Electroencephalography, Arduino Mega 2560, Signal Processing

I. Introduction

Technologies now have roles in many fields to support mankind, including in the medical field. Medical technologies applicating principles and design for medical needs. One of them is Electroencephalography (EEG) that recording brainwave signals activities. [1] EEG technology is used in medical fields to diagnose any brain disease that causes abnormalities at EEG recording. [2], [3] EEG method is commonly used at medical and research purposes since EEG using non-invasive methods and accessible, where electrodes are placed at the scalp. [4] The main reason for EEG usage is to obtain and observe Event-Related Potentials (ERP) that can be achieved from the averages of EEG signals in a specific stimulus at a specific time. [5]

In electrophysiology signals, EEG is counted as weak signals. [6] EEG signals have low voltage which around 0.1 to 200 μV. Amplifiers are needed to boost the voltage into readable voltage range by Analog and Digital Converter (ADC). A very high amount of gains amplifier will boost even unwanted signals, there are 50 *Hz*, used signals from tissue-electrode interfaces, and unwanted hardware signal. [7], [8] EEG usually have four signal components, named Delta (δ) with ±0 – 4 *Hz*, Theta (θ) with 4 – 8 *Hz*, Alpha (α) with 8 – 13 *Hz*, Beta (β) with 13 – 35 *Hz*. Signals with higher than 40 *Hz* will be called signal noise from Electromyograph. [9], [10]

An EEG system usually used to detect brainwave signals for research and medical needs. Detecting brainwave signals need sensors that placed on the scalp, amplifiers because brainwave signals have low magnitudes with μV order, filters to reduce noise and interfaces for monitoring.[6], [7] To obtain signals from the scalp, electrodes made with Silver Chloride (AgCl) are used because it has complete non-polarized characteristics. The Electrodes placed at the scalps must be placed with Ten-Twenty Electrodes System Placement so that the final result could be compared to other EEG devices. [10]

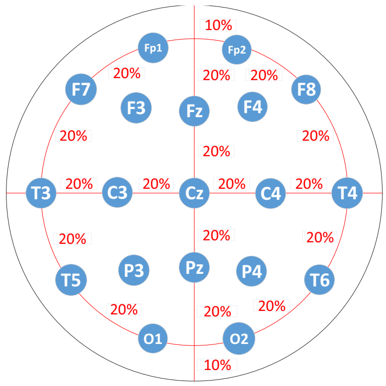

Fig 1. Ten-Twenty Electrode Placement System.

This paper discusses the EEG device that has been built with proposed basic construction and displayed in PC with SCILAB application. Simulation and Construction would be covered later in Section II, which discusses amplifier construction and simulate it with Audio Frequency Generator (AFG) and would read on Arduino Mega 2560 to PC. Section III, will show about signals result that will be displayed on SCILAB application based on Ten-Twenty Electrode System in Fast Fourier Transforms (FFT) graph.

II. Simulation and Construction

Circuit diagram of Electroencephalograph that has been built shown in Fig 2.

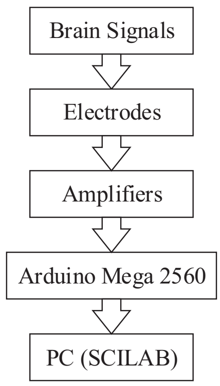

Fig 2. Circuit Diagram of Electroencephalography.

A. Amplifier Construction

Signals that have been obtained from a scalp using AgCl electrodes must be amplified since EEG signals have μV order. The amplifier circuit is shown in Fig 3. In this circuit, IC AD620AN and TL082 are used to amplify with additionals setup from resistor and capacitor combinations. AD620AN is used to amplify signals with high numbers of gain with the equation:

$$G = \frac{49.4\ K\Omega}{R_G} + 1 \quad (1)$$

Where G as a Gain value and R_G as a value of the resistor. The signal output from AD620AN must be filtered with High-Pass Filter (HPF) to remove DC offsets. Frequency cut-off (F_c) equation for first order filter is:

$$F_C = \frac{1}{2\pi RC} \quad (2)$$

TL082 has two functions in this circuit, amplifier and DC offset. TL082 amplifies the signals using inverting gain methods and giving the DC offsets signal with Zener diode. Gain calculations with OP-AMP are using the equation: [11]

$$G = -\frac{R_f}{R_G 1} \quad (3)$$

$$OFFSET = -V_{ref} \times \frac{R_f}{R_G 2} \quad (4)$$

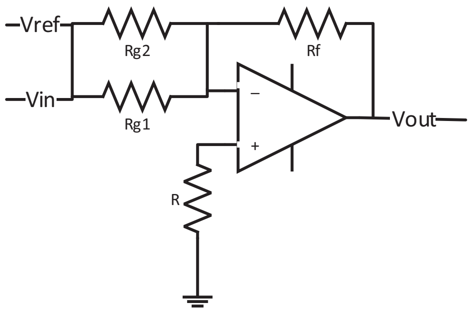

Fig 3. OP-AMP Inverting Gain Amplifier.

The other OP-AMP on TL082 is used to invert the signal back. Lastly, Low-Pass Filter (LPF) is added to filter the utility frequency (50 *Hz*).

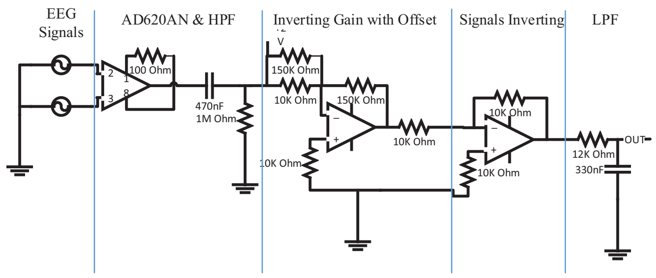

Fig 4. Amplifier Circuit Diagram.

B. *Arduino Mega 2560 and SCILAB Simulation*

Arduino Mega 2560 is used since having 16 ADC that matched with the minimum number of Ten-Twenty Electrode System. Arduino Mega 2560 has 10 bits Analog to Digital Converter (ADC) resolution which can encode an analog input into 1024 levels (2^{10} = 1024). Arduino Mega 2560 ADC simulation result with Oscilloscope reading comparison shown in Fig 5 and 6. PLX-DAQ is used to record signals that have been received from Arduino Mega 2560. PLX-DAQ is an open-source software add-in for Microsoft Excel that acquires data from Arduino Mega 2560. Another function PLX-DAQ is used to calculate Frequency Sampling. PLX-DAQ obtain data with time and timer add-ons. With numbers of received data in a certain time, Frequency Sampling (Fs) is calculated with the equation:

$$F_S = \frac{n}{T} \quad (5)$$

Where n is numbers of signals that have been achieved at a certain time t. Frequency Sampling may differ in different recordings depend on the capability of a microcontroller and clock that has been set.

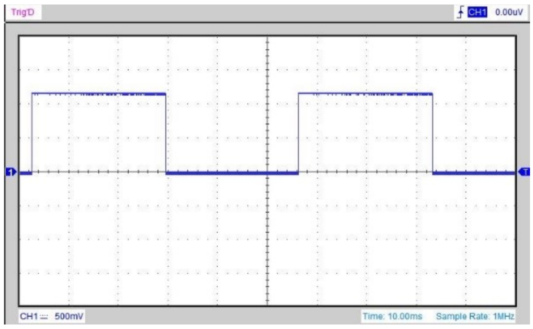

Fig 5. 20 *Hz* Square Wave Displayed using Oscilloscope.

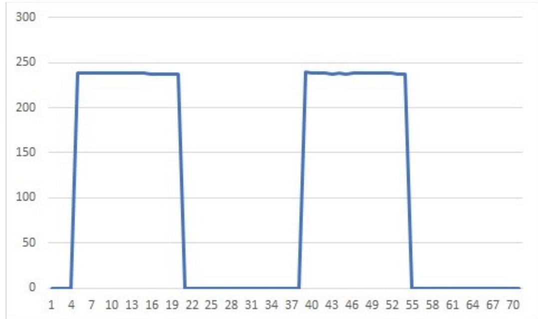

Fig 6. 20 *Hz* Square Wave Displayed using Arduino Mega 2560.

After acquiring data using PLX-DAQ, Recorded signals would be processed in SCILAB software. In SCILAB, signal processed using Butterworth Filter and Fast Fourier Transform (FFT). Butterworth Low-Pass Filter is used to filtering signals with high-order filters, especially utility frequency (50 *Hz*). Butterworth Low-Pass Filter is shown in Fig 7. To convert into readable signals, FFT is used to read what frequencies that creating signals and how many amplitudes on each frequency. Signal Reading simulation is shown in Fig 8.

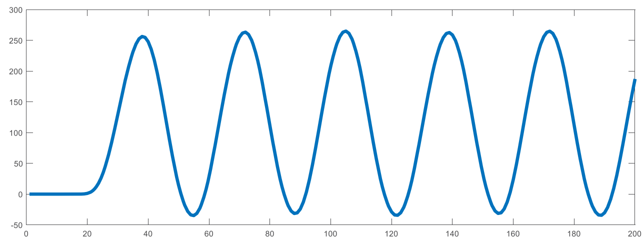

Fig 7. 20 *Hz* Square Wave Filtered with Butterworth Low-Pass Filter.

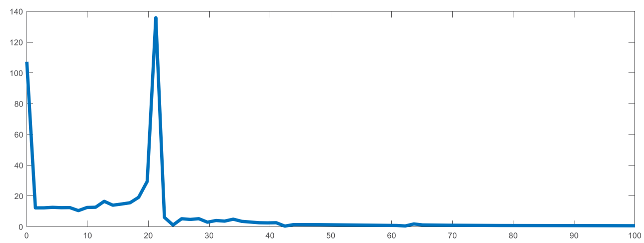

Fig 8. Filtered Square Wave in FFT domain.

III. Result and Discussion

Final Construction is shown in Fig 9 and 10. Signals acquire from a scalp using an electrodes cap with Ten-Twenty Electrode Placement. Acquired signals then amplified with amplifier circuit that contains AD620AN and TL082 which have total gains into 15000 times. Amplified signals are read using Arduino Mega 2560, and shown using SCILAB application. The signals then filtered using 20th order Butterworth Low-Pass Filters 40 *Hz* and converted to Fast Fourier Transform (FFT). Result signals are shown in Fig 11 and 12.

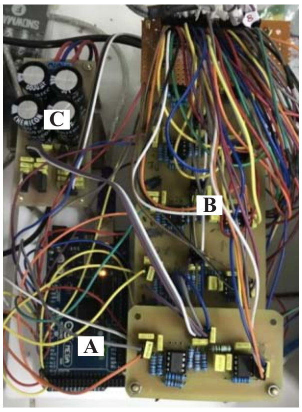

Fig 9. Circuits Construction.

Fig 10. Electrodes Cap.

Fig 9 is electric circuits that have been used, where A is Arduino Mega 2560, B is Amplifier circuits with the amount of 16, and C is the power circuit. Fig 10 is an electrodes cap, where electrodes are placed with Ten-Twenty Electrodes System.

Fig 11 and 12 show the signals result that has been achieved from specific conditions. Both signals are taken in the condition where the subject relaxed, sitting in a chair, and listening to certain music. The differences between them are the condition where the subject closes and opens his eyes.

Fig 11 shown FFT filtered signals in closed eyes condition. These signals have a frequency sampling of 203,8217 *Hz* in 1000 data. Every signal in each point have the same graph forms but has different amplitudes range and ripples in each form. These signals usually have high amplitudes at low frequencies then gradually lower in higher frequency until frequency around 20 – 25 *Hz.* Around here, the lowest amplitude is achieved, then at a higher frequency, the amplitudes are recovered until frequency cut-off at 40 *Hz*. The highest range amplitude is shown in point Fp1 – F7 that has range around 0 – 13 *V* while the others only have 0 – 4.5 *V* at maximum amplitudes, but this point have different graph form and high ripples.

Fig 12 shown FFT filtered signals in open eyes condition. These signals have a frequency sampling of 192,3365 *Hz* in 1000 data. Every signal in each point has the highest amplitude in 11, 22 and 40 *Hz,* with differ amplitudes value order. Unlike closed eyes conditions, Amplitudes range in every signal in opened eyes conditions are higher than closed eyes conditions, with around 0 – 14 as a minimum, where the highest is at Fp1 – F7 point with 0 – 33. The graph form at each point has about the same.

IV. Conclusion

The construction that has been build works well and can be compared with other EEG equipment that has already build. This construction has around 185 to 205 frequency sampling. The result may differ in other conditions like eyes, focusing, concentration, etc. This construction used a conventional micro-controller, common EMG amplifiers and electrodes, and additional amplifiers. This construction may be preferred to the first study of EEG technology.

Acknowledgment

This work was supported by Directorate of Research and Community Service, Directorate General of Research Strengthening and Development, The Minister of Research, Technology and Higher Education, Republic of Indonesia 2019.

References

[1] P. Xavier, K. Behbehani, D. Watenpaugh, and J. R. Burk, “Detecting Electroencephalography Variations Due to Sleep Disordered Breathing Events”, *29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, vol. 29th, pp. 6097–6100, 2007.

[2] J. An and S. Cho, “Hand Motion Identification of Grasp-and-Lift task from Electroencephalography Recordings using Recurrent Neural Networks”, *International Conference on Big Data and Smart Computing (BigComp)*, pp. 427–429, 2016.

[3] S. Zahan, A. Milu, and K. I. Molla, “Rhythmic Component Retrieval from EOG Artifact of Electroencephalography Signals”, *20th International Conference of Computer and Information Technology (ICCIT)*, pp. 22–24, 2017.

[4] C. Im, K. An, C. Lee, H. Jung, and Y. Lee, “Enhancing Accuracy in Magneto- and Electroencephalography Focal Source Localization”, *IEEE Transactions on Magnetics*, vol. 42, no. 4, pp. 1387–1390, 2006.

[5] V. Cencen, M. Hirotani, A. Chan, "Comparison of Active and Passive Electrodes in Their Optimized Electroencephalography Amplifier System", *IEEE EMBS International Student Conference*, 2016.

[6] Z. Xiaodong, "An Approach for Measurement and Recognition of Electroencephalography Analysis for Basic Feature of EEG Signal Neural Network and Hard Activity Recognition, *8th International Conference on Electronic Measurement and Instrument*

[7] T.C. Major, J.M. Conrad, "The effect of Pre-Filtering and Individualizing Component for Electroencephalography Neural Network Classification, *SoutheastCon*, 2017.

[8] A.Y. Paek, A. Gailey, P. Parikh, M. Santello, Jose. C, "Predicting Hand Forces from Scalp Electroencephalography During Isometric Force Production and Object Grasping",*37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 2015

[9] B.T. Jap, S. Lal, P. Fischer, "Using Spectral Analysis to Extract Frequency Component from Electroencephalography: Application for Fatigue Countermeasure in Train Drivers. *The 2nd International Conference on Wireless Broadband and Ultra Wideband Communication*, 2007

[10] S. S. Daud and R. Sudirman, “Effective Environment for Memorizing Process based on Electroencephalography”, *10th Asian Control Conference (ASCC)*, 2015

[11] B. Carter, “Design Gain and Offset in Thirty Seconds”, 2002, Texas Instrument

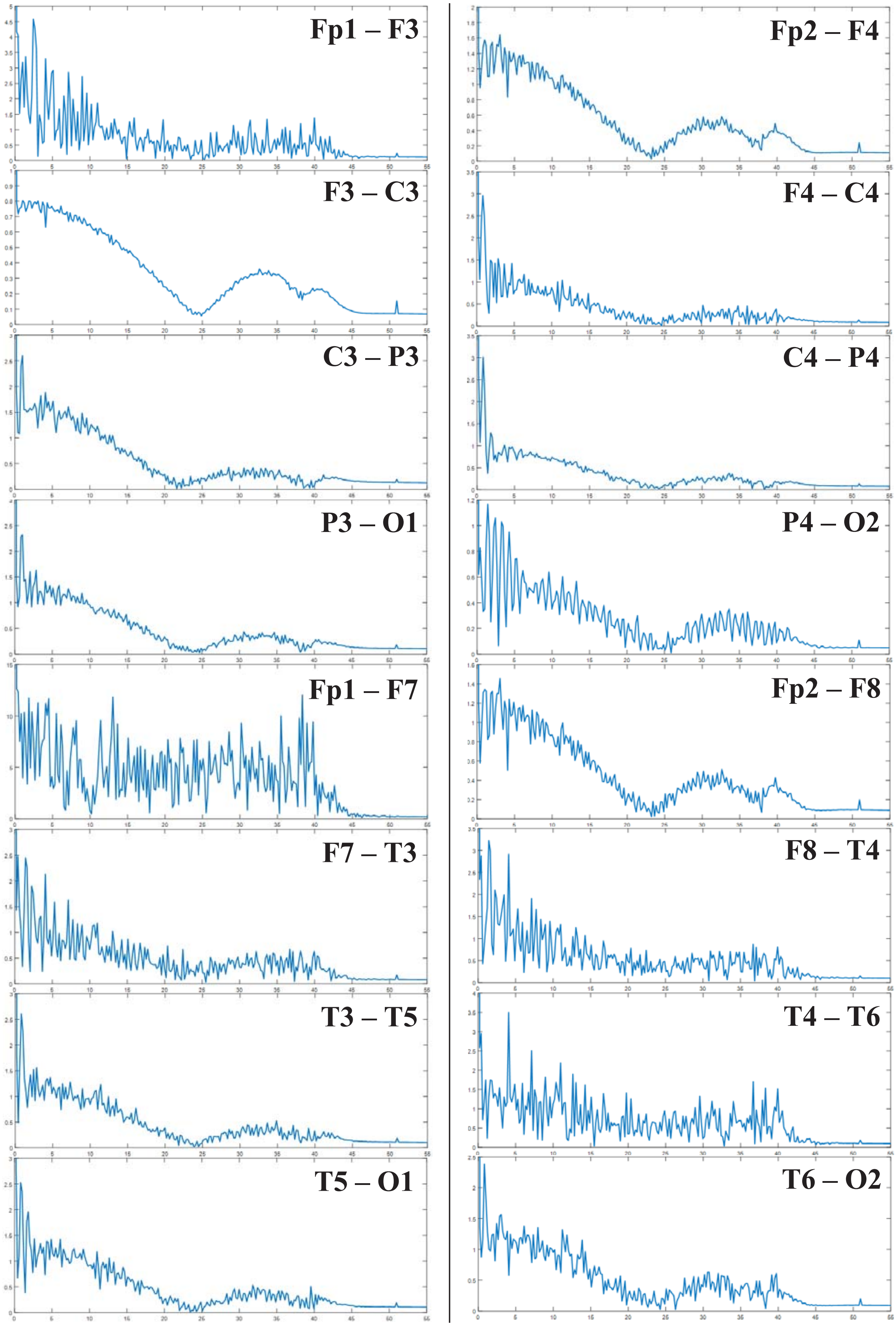

Fig 11. FFT Signals Result in Closed Eyes Condition.

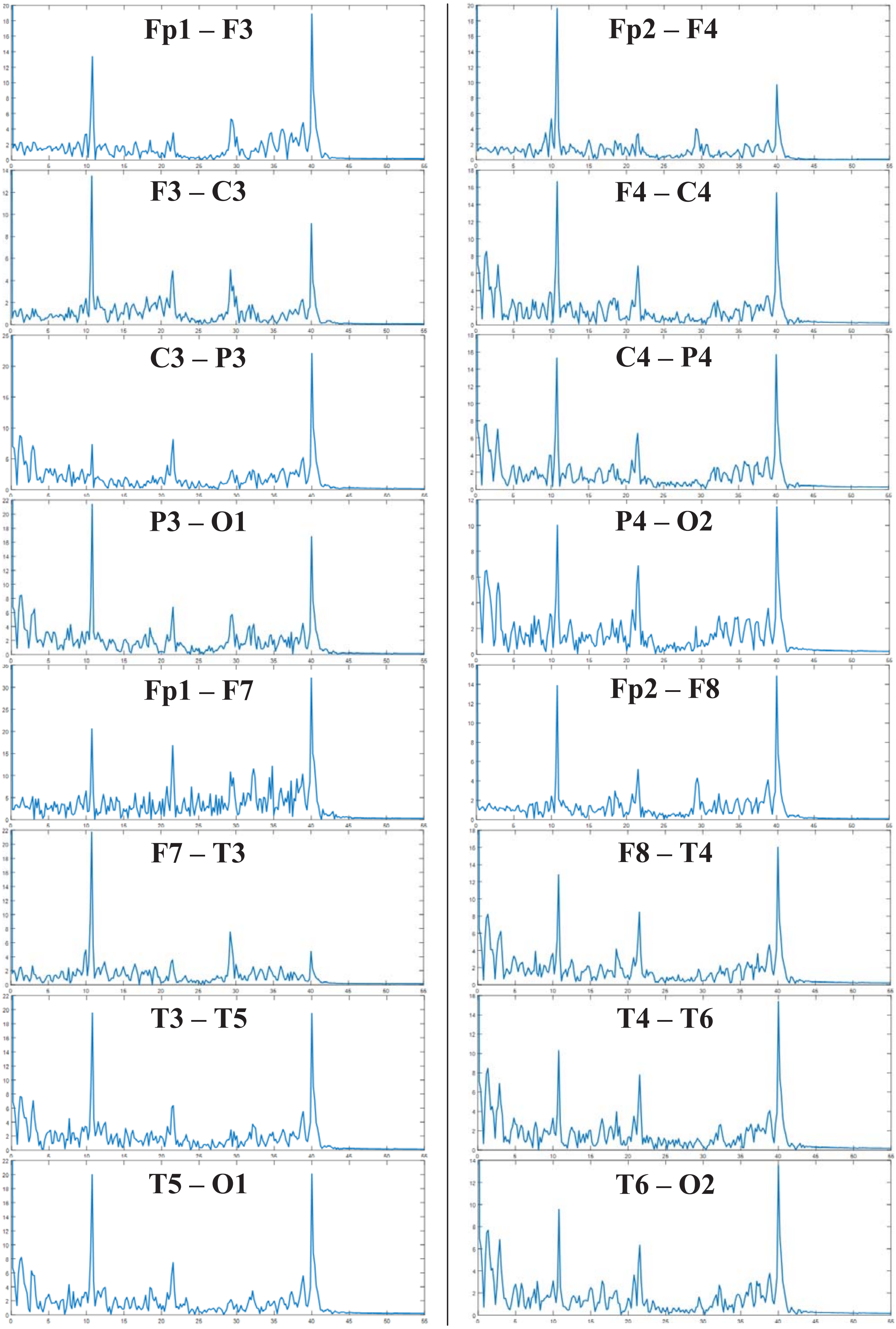

Fig 12. FFT Signals Result in Opened Eyes Condition.