PROCEEDINGS

4th International Conference on Technical and Vocational Education and Training (TVET)

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Technical and Vocational Education and Training for Sustainable Societies

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FOREWORD

Welcome for all respected scholars, researchers, post graduate studentsand especially Keynote Speakers to the 4 ICTVET. The theme of the conference focus on Technical and Vocational Education and Training for sustainable societies and consist of six subthemes. i.e Development of learning model on TVET, Workplace Learning and entrepreneurship, Innovationon applied engineering and information technology, Management and Leadership on TVET, Vocational and Technical Teaachers education, and Assessment and Evaluation on TVET.

Sustainable society shoul be followed by the improvement of various factors that have impacts to the quality of vocational and technical education and training, particularly to overcome the competitiveness of the world business. As we have already known the rapid change of technology as well as the change of demography, having a great effects to the life of peoples in this world, The competitiveness need a collaborativeness to survive the life of millions peoples who lost their jobs. Young peoples as aproductive generation have to be creative and innovative to face the competitiveness. So this prociding contents consist of various findings of research in the field of vocational and technical education as well as applied technology and mainly based on the subthemes of the conference.

Finally, we would like to thank a million for all participants of this conference and all parties who support the success of this conference. Hopefully the seminars and scientific work of this seminar can be a reference material for basic education and elementary school teacher education in Indonesia.

Padang, July 2, 2018

Tim Editor

CONTENT PROSIDING ICTVET 2017 REPOSITORY UNP

THE DESIGN OF THE SIGNAL MEASUREMENT DEVICE OF BODY'S BIOELECTRICAL IMPEDANCE By USING THREE ELECTRODES

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ABSTRACT: This article aims to design the signal measurement device of body's bioelectrical impedance (bio-impedance). Previous measurement methods are less effective because they used four electrodes. While this device is using three electrodes. The device consists of three integrated circuits, i.e. stimulate's circuit, instrumentation's circuit, and minimum system. The design used three electrodes method which one electrode is mounted on the left shoulder, one electrode on the right shoulder, and another is functionalized as the ground which is mounted between the left and the right shoulder. The measured voltage is represented bio-impedance's value. Based on the experiment, the device is able to measure bio-impedance's signal of human's body. The obtained signal could be used as a control signal.

Keywords: bio-impedance, three electrodes, a control signal, measurement

1. INTRODUCTION

The bioelectrical impedance (bio-impedance) is a passive electrical part found in body tissues. The magnitude of bio-impedance varies because it's influenced by muscle contraction that occurs in body tissue. The bio-impedance's measurements can be performed on almost any part of the body as long as the muscles in that part are still functioning or contracting. To measure the magnitude of bio-impedance, the body must be passed a small electrical current through an electrode, then measure the potential difference between two points on the current flowing part. The measured bio-impedance [1] can be known by using Ohm's law.

$$Z = \frac{V}{I}$$

Where V is the voltage and I is the current and Z is the body impedance.

The biopotential electrode is an interface between the body and the electronic measuring instrument. This connector is very important because the current flowing body is the currents in the form of ions. While the current that moves on electronic devices in the form of electrons. Therefore, the electrode is a transducer capable of converting ion currents into electric currents. This current conversion is based on the oxidation-reduction reaction. The electrical currents within the metal move electrons to move from the metal surface and caused oxidation reactions that produce cations. This cation undergoes a discharge (reduction reaction) in the electrolyte. The reactions that arise in the anions are similar; anion toward the electrodes surface and oxidized to neutral and gives some electrons to the electrodes [1].

The electronics model of the electrodes can be understood as in Figure 1 [1]. E_{cell} is half-cell potential, C_d and R_d are the impedance of the electrodes, and Rs is the cable resistance. When this is analyzed, it can be realized that the resistivity of the electrodes will decrease due to the frequency effect, the half-cell potential will also decrease as a result of frequency.

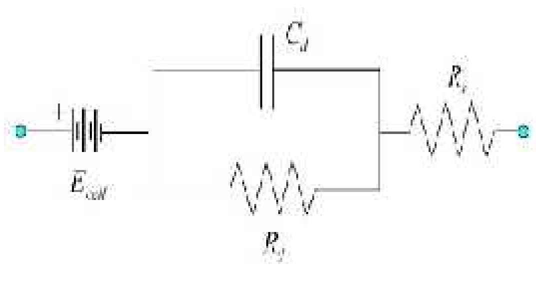

Fig. 1 Mathematical Model of Electrodes

There are two methods of measuring bio-impedance previously, namely bipolar and the tetrapolar electrode. The bipolar method uses two electrodes to flow the current and measure the potential difference, while the second method uses two pairs of electrodes to flow the current and measure the large potential difference. Although bipolar methods are easier, researchers generally [1] [2] [3] [4] [5] [6] [7] used tetrapolar methods in bio-impedance measurement because the measured results were better than the bipolar method. The method of measuring the tetrapolar as seen in Figure 2 [8].

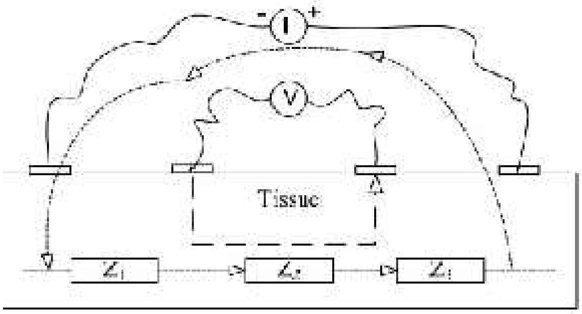

Fig. 2 Four Electrodes Method

The measurement's method of four electrodes is considered to be less efficient and effective since it used too many electrodes for 1 measurement channel. To that end, this article tried to offer another alternative in measuring body bio-impedance. The measurement's method used only 3 electrodes that can measure on 2 channel at the same time.

2. METHODS

In general, the bio-impedance's measurement system consists of a stimulation's circuit and instrumentation's circuit. The stimulation's circuit is a circuit which alternates current source with a frequency of 50 KHz and a maximum amplitude of 0.5 mArms. Then, the current will be injected into the body through an electrode. The other part is a series of instrumentation. This circuit is used to measure potential differences in the simulated body. The measured voltage represents the value of bio-impedance [9].

The voltage is amplified by using instrumentation's circuit amplifiers that have a high common mode rejection ratio (CMRR) capability. Once amplified, the voltage is passed to the band pass filter circuit to take the desired frequency, ie ± 50KHz. Thus, the voltage data will be spared from electromyography (EMG) signal interference ranging from 20Hz to 500 Hz, artificial movement disturbance, and radio wave interference. The output voltage of the filter circuit then goes into the circuit of the voltage rectifier in order to facilitate the microcontroller in retrieving and processing the data. In this articles used 2 series of stimulation and 2 pieces of instrumentation to perform measurements on two channels simultaneously. The system requires three electrodes. The diagram block of the system is showed in Figure 3.

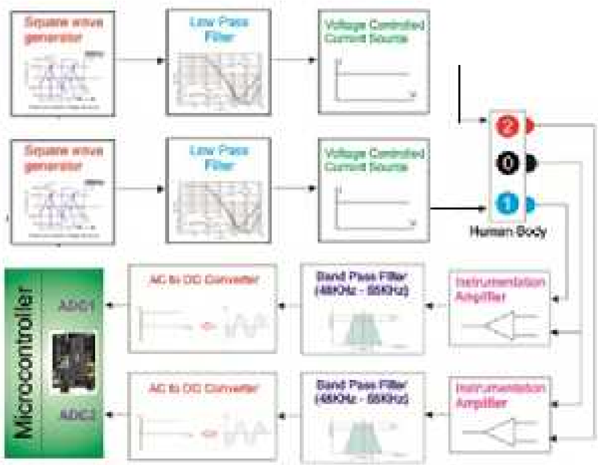

Fig. 3 Diagram Block of Bio-impedance Measurement System

2.1 Stimulation's Circuit

This circuit aims to generate an alternating current source with a frequency of 50 kHz and a maximum amplitude of 0.5 mA. The stimulation's circuit consists of sine wave generator and voltage controlled current source (vccs).

2.1.1 Sine Wave Generator

The sinusoidal signal generating circuit consists of square wave generator circuit, low pass filters, and non-inverting amplifiers. The square wave generator circuit aims to produce a square signal as free running with the addition of setting the frequency of signal output. The desired output frequency of this circuit is 50 KHz. The low pass filter circuit is used to obtain the output of a sinusoidal signal from the square signal input of the square wave generator circuit. The Cut off frequency of this LPF circuit is set to equal the frequency of the signal generated by the square wave generator circuit which is 50Khz. The non-inverting amplifier circuit is used as the voltage amplitude regulator of the sinusoidal signal generated by the low pass filter circuit.

2.1.2 Voltage Controlled Current Source (VCCS)

The function of VCCS's circuit is to convert a sinusoidal voltage signal into a sinusoidal current signal which will be injected into the patient's body through the electrode. This circuit is composed of two op-amps that have a bandwidth gain of 3 MHz, low current bias current (50 pA), and high slew rate (10 V/μs).

2.2 Bio-impedance Instrumentation's Circuit

This circuit is used to measure potential differences in the simulated body. The measured voltage represents the amount of bio-impedance. The instrumentation circuit consists of amplifier instrumentation's circuit, bandpass filter, AC to DC converter, and differential amplifier's circuit. The function of amplifier instrumentation's circuit is to strengthen the measured bio-impedance's voltages. Bandpass filter served to remove noise and to pass the frequency with a range of 45 kHz to 55 kHz. AC to DC converter aims to convert Ac voltage into DC voltage. The differential amplifier function as a final amplifier before it's processed by a microcontroller.

The installation and placement of electrodes for measuring bio-impedance are performed on the back/shoulders as it has the most optimal bio-impedance [7]. In addition, the section also provides many alternatives to provide the control signal. Figure 4 shows the positioning of the electrode.

Fig. 4 The positioning of three electrodes

3. RESULT AND DISCUSSION

3.1 The Test of Simulation's Circuit

3.1.1 The Test of Square Wave Generator Circuit

This circuit serves to generate a square wave with an adjustable frequency. The conducted experiments result that this circuit can generate frequency's range between 23 KHz and 238 KHz. Since this study required a frequency of 50 KHz. The output signal of this circuit is shown in Figure 5.

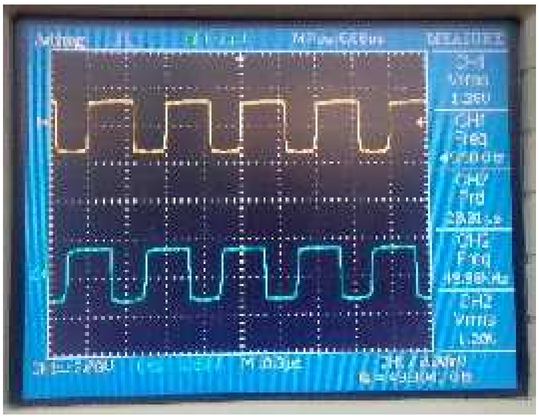

Fig. 5 The output signal of *square wave generator* circuit

3.1.2 The Test of Low Pass Filter

The test of low pass filter circuit is done by providing sinusoidal voltage input with constant amplitude. The frequency of voltage varied from 1 KHz to 500 KHz and measured output voltage using a voltmeter. Figure 6 is graphic of the frequency response of the LPF circuit and the output signal.

Table 1 Result of the test of LPF's circuit

V_{in} (Volt)	F_{in} (Hz)	V_{out} (Volt)	Gain (V_{out}/V_{in})
500	1000	740	1.1923
500	5000	740	1.1923
500	10000	720	1.1730
500	15000	690	1.1442
500	20000	700	1.1538
500	25000	680	1.1346
500	30000	690	1.1442
500	35000	670	1.125
500	40000	610	1.0673
500	45000	510	0.9711
500	50000	359	0.8259
500	60000	348	0.5269
500	70000	327	0.3144
500	80000	200	0.1923
500	90000	131	0.1259
500	100000	88.7	0.0852
500	200000	6.38	0.0061
500	300000	1.74	0.0016
500	400000	0.814	0.0007
500	500000	0	0

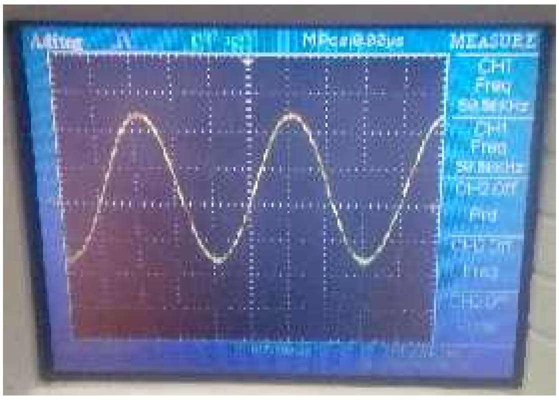

Fig.6 Output signal of Low Pass Filter circuit

3.1.3 The Test of Inverting Amplifier Circuit

The function of this circuit is to regulate the amplification of the sinusoidal signal generated by the LPF so that it can easily adjust the signal amplitude desired. In this system, the designed sinusoidal signal generated has a value of 2 Vrms. Figure 7 is the output signal of the inverting amplifier circuit.

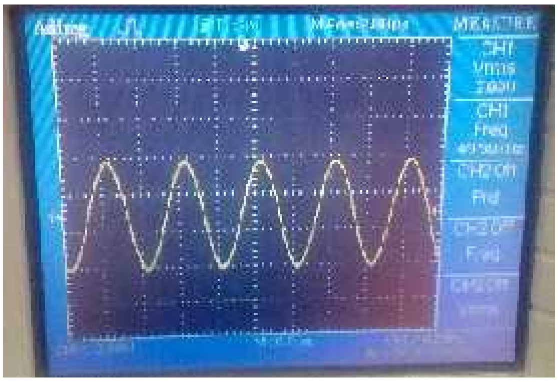

Fig.7 Output signal of Inverting Amplifier Circuit

3.1.4 The test of VCCS's circuit

The output of this circuit is set to produce a sinusoidal current with a frequency of 50 KHz, as well as a constant amplitude of 0.5mA. With 2V input signal amplitude, the multi-tune is set to have a resistance of 1 KΩ. The test of this circuit is done by using multi-tune of the 5K variable resistor. Table 2 is the result of the test of VCCS's circuit.

Table 2 Result's Data of VCCS's circuit test

Resistance (Ω)	No Load Current (mA_{rms})	Measured Current (mA_{rms})	Error (%)
100	0.5	0.499	0.2
200	0.5	0.498	0.4
300	0.5	0.497	0.6
400	0.5	0.496	0.8
500	0.5	0.495	1
600	0.5	0.494	1.2
700	0.5	0.492	1.6
800	0.5	0.49	2
900	0.5	0.49	2
1000	0.5	0.488	2.4

When the variable resistor is not installed, the VCCS's circuit is only connected to the amperemeter. In the initial conditions, I_{out} is set to a value of 0.5mA. From the test results, if the resistor value is high, then the error is also high. This indicated that the voltage controlled current source circuit is still not stable enough to produce a constant current with varying loads. this is not a problem in the application of bio-impedance measurement in the back area, because the impedance's range is not too big which is about 250Ω - 270Ω [8].

3.2 The Test of Instrumentation's Circuit

3.2.1 The Test of Instrumentation Amplifier

This test is performed by measuring the level of linearity from amplification of this instrumentation by using the input of the sinusoidal signal generator function. In the process of the multitude's test is set to have a gain of 10 times, so Rgain = 2x22kΩ / (10 - 1) = 4.89kΩ. The test's result for some input signals is shown in Table 3.

Table 3 The test's result of instrumentation amplifier circuit

V_{in} (mV_{rms})	V_{out} (mV_{rm}s)	Gain (V_{out}/V_{in})
100	1003	10.03
150	1536	10.024
200	2063	10.315
250	2572	10.288
300	3059	10.196
350	3583	10.237
400	4104	10.26
450	4560	10.13
500	5070	10.14

From the above experimental results can be concluded the amplification of the r amplifier instrumentation data is quite linear.

3.2.2 The Test of Band Pass Filter (BPF)

The test on this circuit is performed to see the frequency response of the Band Pass Filter circuit.

The cut-off frequency is between 48KHz anf 55KHz, or center frequency is at 50kHz. The input signal used is a sine wave derived from the function generator with an input voltage of 1 V_{rms}. The frequency varied from 1 KHz to 500 KHz, and the output voltage is measured using an Avometer. The test results from this BPF's circuit are shown in Table 4 below.

Table 4 The test's result of BPF's circuit

V_{in} (V_{rms})	fin (KHz)	V_{out} (V_{rms})	Gain (V_{out}/V_{in})
5	1	0	0
5	10	0.09566	0.019132
5	20	0.94722	0.189444
5	30	3.93141	0.786282
5	40	4.42912	0.885824
5	50	5.02492	1.004984
5	60	4.54289	0.908578
5	70	4.13719	0.827438
5	80	3.87723	0.775446
5	90	2.02039	0.404078
5	100	1.37764	0.275528
5	200	0.708546	0.141709
5	300	0	0
5	400	0	0
5	500	0	0

The result of the BPF's test above showed that the center frequency lied at 50 KHz. This is proven at that frequency the voltage gain is the greatest gain.

3.2.3 The Test of AC to DC Converter

This test is done by providing input to the circuit of 50Khz sinusoidal signal which generated from function generator with some variation of voltage amplitude. The output voltage is a DC voltage is shown by a voltmeter which is then compared with the RMS voltage of its input signal to determine the error of this circuit. The test results are shown in Table 5.

Table 5 The result's test of AC to DC converter circuit

V_{in} AC (Vrms)	V_{out} DC (Volt)	error (Volt)
0.5	0.41	0.09
1	0.93	0.07
1.5	1.34	0.26
2	0.95	0.05
2.5	2.48	0.02
3	3.04	0.04
3.53	3.23	0.27
4	3.65	0.35
4.5	4.13	0.37
5	4.57	0.43

3.2.4 The Test of Differential Amplifier Circuit

This circuit is used to adjust the DC voltage output from the AC to DC converter so that the value will vary from 0-5 Volts. Thus, the output of this circuit is a DC voltage with a maximum voltage of 5 Volts and it's ready to be inserted into the ADC microcontroller.

3.3 The Body Bio-impedance Measurement

This measurement is intended to determine the magnitude of impedance changes on the back/shoulders. The measurement was made by moving the right and left shoulders from the normal position up to the maximum and recorded the changes in voltage that occur. The test was conducted on five samples. The impedance is obtained by dividing that voltage by a large flow of stimulation. Table 6 shown the measurements on the right and left shoulders.

Table 6 Result of measurements on the right shoulders

No.	Name	Measured Impedance (Ω)		Impedance Change (Ω)
		Normal	Contraction	
1	Yudi	137.0832	152.4007	15.3175
2	Dharma	196.0295	203.6045	7.575
3	Andi	164.7954	175.9647	11.1693
4	Ahmad	178.5674	188.4387	9.8713
5	Robi	184.6490	189.6852	5.0362

Table 7 Result of measurements left shoulders

No.	Name	Measured Impedance (Ω)		Impedance Change (Ω)
		Normal	Contraction	
1	Yudi	154.8362	162.8298	7.9936
2	Dharma	174.8294	178.7382	3.9088
3	Andi	139.2847	145.8345	6.5498
4	Ahmad	156.2193	163.7301	7.5108
5	Robi	129.8453	139.3493	9.504

From table 6 and 7, it's known that the bio-impedance measurement system is designed to measure the body's bio-impedance value for all samples tested. Table 6 is the measurement result on the right shoulder and Table 7 is the measurement result for the left shoulder. There is a change in the value of bio-impedance in normal circumstances compared to muscles when contract. The test results also show that the value of bio-impedance when the muscle contracts larger compared to normal condition. On the right shoulder, the changes in bio-impedance values occurred between 5.0362 Ohm and 15.3175 Ohm. While on the left shoulder the change in bio-impedance values that occurred between 3.9088 Ohm and 9,504 Ohm. The changes in bio-impedance values also caused the changes in measured bio-impedance voltages which will be used as a control signal in a system.

4. CONCLUSION

The design of body bio-impedance measurement system with three electrodes methods successfully done. This device is able to measure the body's bio-impedance signal on two channels simultaneously. There is a change in the bio-impedance value of the body when muscle tissue contracts compared to normal circumstances. On the right shoulder, an average change in body bio-impedance value of 9.7938 Ohm, and on the left shoulder of 7.0934 Ohm. The changes in body bio-impedance values are proportional to the result of the changes of bio-impedance voltage. The voltage changes that occur can be used as a control signal in the system.

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