Utilization of Myo-Electric Signal on Muscle Contraction Process as Trigger for Actuator Motor Movement

Susy Susmartini*), Djoko Roeshadi, Isa S. Toha, Angela B. M. Tulaar

***Abstract* —In Indonesia, there are many people suffering the loss of their hands due to accidents or other causes that asking for prosthesis as the artificial hand. They are difficult to get the prosthesis since it is very expensive and a dependent imported product. This research discusses Myo-Electric Signal (MES) device as an initial engineering of prosthesis as Myo-Electric artificial hand product. We propose the processing device by utilizing MES on muscle contraction process using surface electrodes without an external electrical stimulator. The device was developed and is able to seize the MES beneath skin surface ranging from 30-40 mVolt, to filter noise out of the MES , to reinforce input, and to calibrate the MES as a drawing shape. The proposed-device can be used to detect MES, to reinforce 150 times the tension in the range 0 to 5.63 Volt, to spin actuator motor while the muscle is contracted, and to stop spinning when the muscle is relaxed.**

***Index Terms*— Actuator Motor, Artificial Hand, Muscle Contraction, Myo-Electric Signal.**

I. Introduction

THE National Health Census of the Department of Health in 2001 showed that disability prevalence in Indonesia is 39 % [1]. During 2006, at Prof. Dr. Soeharso Orthopedic Hospital in Surakarta, the lower limb amputation (leg) is about 25 % from all hospitals rate, whereas upper limb (arm) amputation is about 15 %, consisting of 10 % above the elbow and 5 % beneath the elbow [2].

Prosthesis application on people with disability, as a condition , is one of the methods to overcome the disability of limbs. Expectantly, the limb disability can be replaced with a prosthesis and help those people to fulfill their daily function. Nowadays, there are 2 (two) kinds of well-known hand prosthesis in Indonesia, namely cosmetic acquirement prosthesis and shoulder movement based hand prosthesis that requires quite a lot of energy, it also provides only pincers movement [2]. Meanwhile, myo-electric artificial hand is an artificial hand with desirable movement [3]-[7]. The input to operate is myo-electric from its user's body.

Not a lot of energy needed to operate it and only requiredto concentrate when the user moves their real hand. However, the device is very expensive and a dependent imported product. Thus, this research is focused on how to utilize of Myo-Electric Signal (MES) on muscle contraction process as a trigger for actuator motor movement.

This paper is organized as follows. In Section 1, we propose the background of our research in real systems. In Section 2, we construct the research methodology. In Section 3, we provide the procedure for collecting data and research results. In Section 4, we deliver the conclusion and future research.

II. Research Methodology

The conceptual frame of this study is shown in Fig. 1. This figure describes the mechanism of proposed-device. The device can be used to detect MES, to reinforce tension, to spin actuator motor, and to stop spinning when muscle is relaxed.

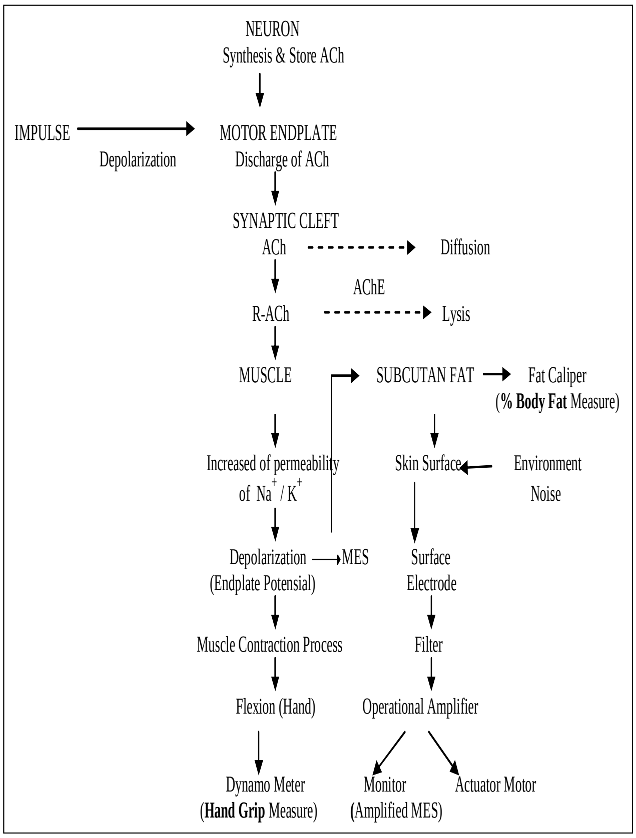

Fig.1. The conceptual frame that discribes the basic of thinking and research variable relationship

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Acetylcholine (ACh) are produced by motorneuron cell, then stored in the end of Axon. When the impulse that will be carried by motorneuron arrived at the end of Axon, then ACh will be released (as transmitter) to “synaptic cleft” and will be received by a unique receptor (R-ACh) in “neuromuscular junction”. The compound of the transmitter-receptor will change Na^+ and K^+ permeability in the muscle, and causes a decrease in the End-Plate Potential (EPP). When the EPP reaches a critical point, it will generate MES [8], [9].

The MES Captor and processing device should be capable to seize the MES on muscle contraction process beneath skin surface (as reference) ranging from 30 to 40 mVolt, using electrode surface without any external electric stimulator; filtering MES out from noise (from 220 Volt/50 Hz network); and reinforcing input and calibrating MES to become drawing shape or mechanical movement [8], [9]. Reference [10] is used to construct the seize and processing of the MES Captor. The MES Processing device is designed with the needs and constraints that exist, whether originating from within the body, as well as those originating from outside the body (the environment), that is:

A. Needs

The MES captor should be able to:

1. Detect MES in muscle contraction process by using a surface electrode, although without external electric stimulator.
2. Muffle the noise that comes from within and from outside the body (electromagnetic radiation) so it does not interfere with the recording MES.
3. Provide output that can be read via the computer screen/ oscilloscope.
4. Manipulate the SME detected so as to drive the motor actuator (the small size Direct Current (DC) motor is used in the motor actuator).

B. Constraints

The MES Captor system is expected to overcome the noise that comes from:

1. Environment, namely:
   a. The electromagnetic radiation from a network of 50 Hz electrical power and non-linear electrical equipment is installed in 220 V/ 50 Hz electricity network.
   b. The radiation is utilized from the radio equipment, such as mobile phones, radio transmitters broadcasting, radio communications, and all lighting equipments.
   c. It is conduct the non-linear electrical equipment and appliances that use electric motors, which spreads through electrical wires.
   d. It is also required independent of the grounding system.
2. In the body, namely:
   a. Load or electrostatic voltage in the body.
   b. Moisture and chemical properties of the skin surface of the hands can affect probe/electrode captor MES.

The output of the whole system is expected to provide a voltage or control one or more devices, which require the input voltage between 0 volt and 6 volts. Thus, which serves as an indicator of success, is MES detected on the oscilloscope screen and computer monitor screens, so that can be known the magnitude of MES, as well as can turning the DC motor, when the process of muscle contraction occurs. Input voltage required by the DC motor used to rotate without load is equal to 0.5- 5 Volt.

III. Procedure For Collecting Data And Result

First, we collect data for validation of the MES Captor and the MES Processor equipment. Second, we collect data from MES Captor and the MES processor equipment components.

A. Engineering Process

The first step taken in the engineering process of the MES Catptor and the MES Processor equipment is prepare the block diagram and the circuit diagram system. The circuit diagram system is structured based on needs, constraints, and factors that must be avoided. Next step is to follow by the procurement of the necessary components and prepare the testing equipments and the measuring instruments.

Each component in a circuit MES Captor device must be conducted preliminary testing by using analog multimeter SANWA type YX-360TRF. This test is to ensure that all components are in accordance with the requirements (*i.e.* requirement of voltage and resistance). The preliminary test carried out again before the components aremounted on a bread board (the process of preparation of the circuit) using a digital multimeter SANWA CD800A to obtain a more detailed test results. Then, on each filter should be tested by using the Function Generator and by giving the input voltage.

Testing of common-mode rejection ratio (CMRR) electrodes to be used is also conducted by using Function Generator, which is set by giving the input voltage, and then measuring the amount of its output. After all the components in accordance with the specifications required, carried out the process of assembly the MES catcher dan processor system on a bread board. Initial testing was done after MES catcher and processor system is assembled, conducted tests at the circuit using the oscilloscope.

Overall, after a whole circuit is built, the tests performed on the CMRR system, also by using a function generator and oscilloscope. As an indicator of success in changing the MES catched into a movement, we use the small size of the DC motor which is equipped with a DC power amplifier in the circuit. Then by using the input that comes from the Function Generator conducted a series of tests. DC motor requires a voltage of 0.5-5 Volts to rotate with no load, which is mounted on the end of the system output (the input is generated by the function generator).

When the initial testing results are considered good, namely that the motor can rotate well as expected, then performed the catching of MES of the hand muscle contraction process involving groups of people with hands healthy/normal.

B. The Testing Results of MES Cather and Processor Equipment Components

Component testing begins by testing the voltage and resistance of each component which has been prepared /

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purchased, using an analog multimeter SANWA typeYX -360TRF, to obtain assurance (in a quick look way), that these components are preferred components. Tests carried out again just before the component mounted on a bread board (the process of assembly of the circuit) using a digital multimeter SANWA CD800A, to obtain more accurate test results.

Then on each filter to be used, the testing done by using the function generator and oscilloscope. By adjusting the function generator to provide the input voltage of 1 volt and a frequency of 50 Hz, it turns out the filter gives an output of 8 mVolt. When given the input 0 to 5 Hz, the filter gives an output of 1 volt. Then, when given input 6 Hz, the filter gives an output of 0.7 volts. At 50 Hz input, the output of 8 mVolt, and at 100 Hz input, the output is not measurable because it is very small.

Testing of common-mode rejection ratio (CMRR) electrodes to be used, also performed by using an oscilloscope and function generator, which is set by giving the input voltage of 1 volt and a frequency of 0-100 Hz, then the resulting output is 8 mVolt. Overall, after the series finished, the CMRR of the system is tested against, also by using a function generator and oscilloscope. When given the input of 1 Volt on the ground and the frequency 0 -100 Hz, this circuit gives an output of 8 mVolt.

After initial testing of the circuit of MES Catcher and processor device is done, and when added DC Power Amplifier into the circuit, the next test is still using inputs derived from the function generator, and use the oscilloscope as monitoring tools. Circuit testing is then performed using a DC motor as an indicator of the entry of an electrical signal. DC motors used requires a voltage of 0.5 to 5 volts to rotate with no load, which is mounted on the end of the system output (the input is generated by the function generator). When the initial testing results are considered good, namely that the motor can rotate well as expected, then tested with the involvement of participants, to get the MES of the process of contraction of hand muscles.

C. Reading Results of MES Data Collection

Participation of participants in a phase II study participants offered to men and women, aged 18-24 years, through an affidavit charging a willingness to study participants. Willingness forms that spreaded are 40 (forty) copies, but who expressed willingness only 22 (twenty) of participants. In the process of data retrieval, 2 (two) participants stated resigned. Adequacy of data to be considered through the normality test data, using SPSS software program 14.

The series/sequence of movements performed are grasping movements (flexion) and re-relax with the open palm of the hand (extension), each with a duration of motion as follows (all done with your left hand):

1. 15 seconds fingers are in a relaxed state
2. The motion of flexion / hold and held for 15 seconds
3. Extension motion and relax the fingers for 15 seconds
4. Flexion movement back and held for 15 seconds
5. After that finger extension exercise and relax.

By using a wire probe neutral wrapped over partisipants' arm above the elbow participants, and two electrodes of MES catcher at two selected points below the elbow, which are thought to be the closest point to the muscle belly of certain muscles, observations were made using the oscilloscope (see Fig. 2 and Fig. 3). Then followed observations by connecting the circuit to the computer monitor screen by using the AUDACITY program.

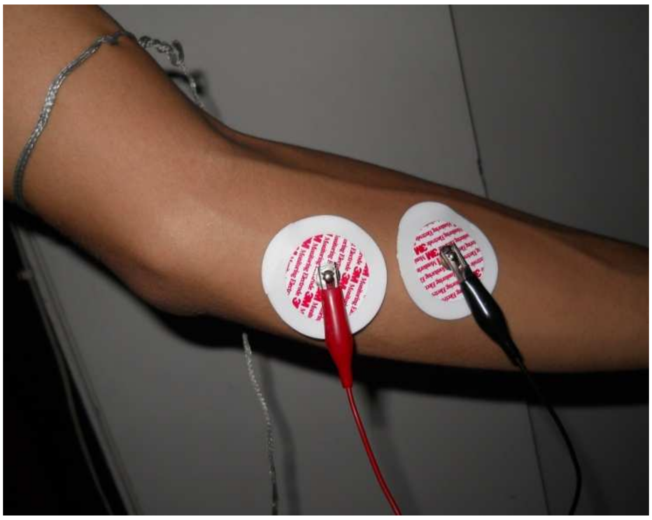

Fig. 2. Allocate neutral probe and electrodes of MES catcher.

Fig. 3. Allocate neutral probe and electrodes of MES catcher in amputee.

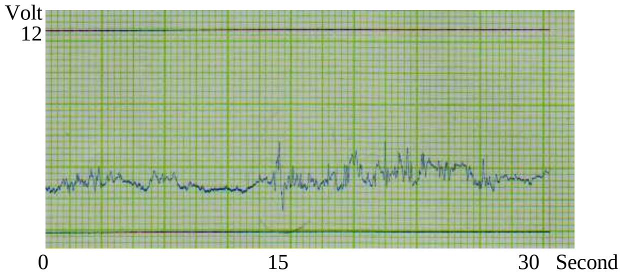

Fig. 4. The MES detected and leveled up by MES Captor and Processor.

Fig. 4 illustrates the MES detected and leveled up by MES Captor and Processor. At the time of the fingers (left) is driven, open (extension) and closing (flexion), is obtained which has enlarged the picture MES (MES enlargement process occurring within the system of Catcher and

Processor) in a span of 30 seconds, which is 15 seconds the first show MES when the muscles in a relaxed state and 15 seconds later shows the SME when the muscles in a state contraction.

By using two electrode for the detection of MES, two active filter "-40 dB/decade Butterworth Low Pass Filter" with 6 Hz cut off frequency, Differential Amplifier and Buffer circuit, the output can be observe through oscilloscope, monitor screen of computer, and actuator motor movement after adding DC Power Amplifier. Overall, this system (with CMMR = 82 dB) can be overcome inducing noise from 50 Hz. building electrical devices.

The result of block diagram of the MES seizing and processing device is illustrated in Fig. 5. From the value of MES that measure with the seizing and processing device/system, found a reality that for a certain finger movement, there was MES value above a muscle belly that the biggest among MES from several muscle that has the same function for the movement. So further that location can be selected to seize MES in order with the desirable movement. The amputees have enough MES and able to move the actuator motor, as long as they always do exercise their muscles.

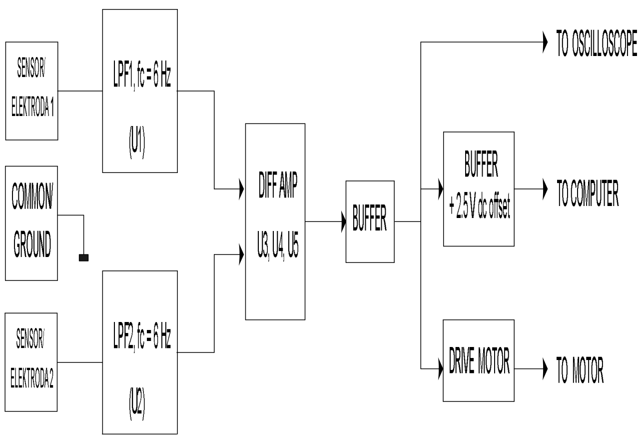

Fig. 5. Block diagram of the MES seizing and processing device.

The other result of the research is there is correlation between MES, hand grip, and body fat percentage. Measuring/searching data of those three variable involving normal hands of 20 persons. Based on statistical analysis, this result could be concluded that each variable correlate one another, both positive and negative. MES correlate positively with hand grip, but negatively with body fat percentage. Through linier regression approach, we found a mathematical formula to estimate MES value both by hand grip quantity or body fat percentage.

IV. Conclusion And Future Research

This research was developed an initial engineering step for creating a myo-electric artificial hand. The device can be used to identify the quality of muscle activities, to train muscle contraction of the patient with amputated hand before using myo-electric artificial hand, and to train the patient in maintaining their health so their muscles could be at their best shape and function.

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