Proc. of 5th Int. Symp. on External Control of Human Extremities, ETAN, Yugoslavia, Dubrovnik 1975.

EXPERIENCES WITH NEW TWO CHANNEL CONTROL SYSTEMS FOR EXTERNALLY PWOERED ARM PROSTHESES

H. Steffens, G. Asher

Abstract

The problem of controlling more than two degrees of freedom in an upper arm prostheses becomes difficult, if the amputation level increases. As the neccessary sources are not available at the stump, new control sites must be found outside the stump area, without reducing the patients mobility.

Signals outside the stump can be picked up by using mechano-electrical trnasducers which registrate forces or variing length in the patients harness system. They can be handled by the patient easily, need less power than mechanical solutions, and offer a good feedback. Two control systems of this type have been developed at the Institute for Orthopaedic Aids of the Technical University of Berlin. They need a maximum force of 4 kp and can be adjusted to some extend to individual conditions. The transducer consists either of a linear potentiometer or a strain gage transducer.

The other possibility is to control more than one movement with the EMG of a single stump muscle by using a two channel amplifier with proportional control. This has also been done at the above mentioned Institute. Both systems were tested on a small number of patients. The findings of these field tests are presented in the contribution in detail.

Introduction

In the upper arm prostheses there is the problem, that the number of degrees of freedom grow, it the amputation level increases. The possible movements habe to be controlled by the patient, but the quantity of available sources at the stump get less. The missing control sources may be obtained by the patients harness

Two channal amplifier with proportional control

The principle of this control unit is shown in figure 1:

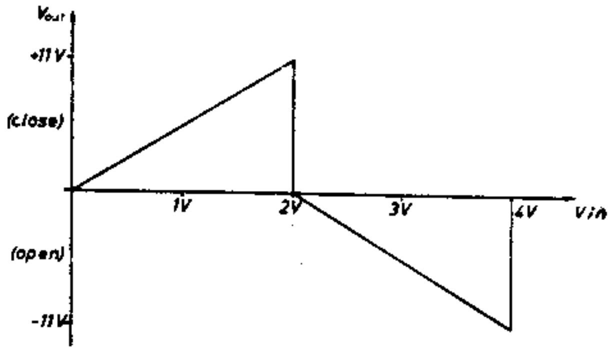

Figure 1

The input voltage V_{in} is an amplified and recified EMG or a voltage, that is obtained from the mechanoelectrical transducer in the patients harness system. The extractions of these signals are discribed later. The output voltage V_{out} controlls a motor, for instance of a hand or an elbow joint. In the following text an EMG controlled hand will be the example.

In the first range up to an input voltage V_{in} of 2 V, it is simply possible to regulate the muscle contraction quantitativly. In the first range the hand closes, the second range is used for open. The input voltage V_{in} varies in the range between OV and + 4 V, the output voltage V_{out} from - 11 V to + 11 V, because the battery has a voltage of 12 V. The circuit, working on this principle, shown in fugure 1, is a two channal amplifier with proportional control in both directions, e. g. open and close of the hand. This simple control unit has some advantages, but two hard disadvantages:
1 st: If an objekt taken by the patient slides out of his hand he will contract the muscles more strongly. This means, that the

input voltage V_{in} gets into the secound rage, so the hand opens instead of some more closing.

2nd: While the patient opens the hand, the input-voltage V_{in} gets higher than 2 V. If the muscle contaction gets less V_{in} goes down to O V. During this time the input voltage passes through the first range and the hand closes a little. Both errors are avoided in this new development. The first error is eleminated by inserting a timing constant T . The diagram on figure 2 showes how it works.

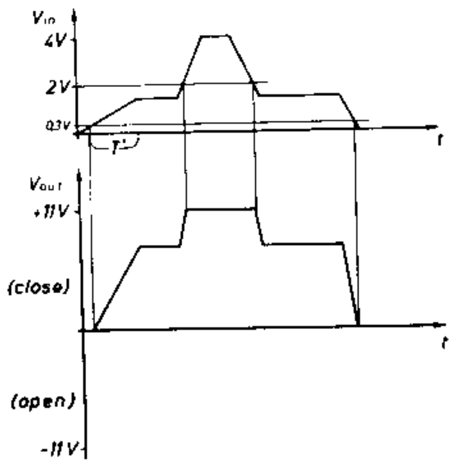

Figure 2

If the patient takes an objekt, he contracts the muscles and the input voltage reades a O,3 V trigger-level. Griping a thing the input voltage must stay longer than T (O,5 seconds) in the first range between O,3 V and 2 V. If this happens, the patient may grip as strong as he wants, e. g. while the objekt slides out of the fingers, so the input voltage gets higher than 2 V, but the output voltage, i. e. the motor-voltage, does not turn round. The positive range of the output voltage can only be left if the input voltage V_{in} drops below O,3 V.

The second error can be avaided by suppressing the first rnage, if the second is reached. This relation is shown in figure 3.

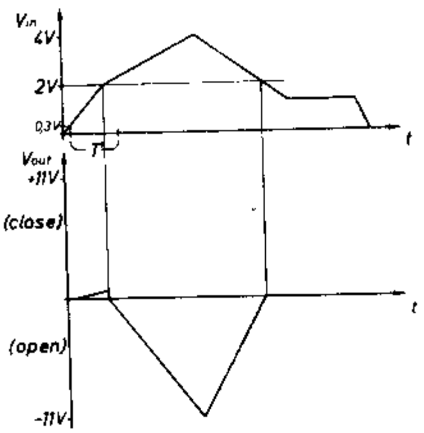

Figure 3

The second range can be reached, if the input voltage gets up to 2 V in a shorter time than T . Now every level V_{in} between 2 V and 4 V gives an output voltage from 0 V to - 11 V, e. g. the hand opens. V_{out} is always 0 V, if V_{in} moves between 0,3 and 2 V. The range of opening can only be left by an input voltage below 0,3 V. To get from one range into the other, it is nessesary to relax the muscles.

Input circuits

As indicated the input circuits are an EMG-amplifier or a mechano-electrical transducer. The EMG amplifier supplies a voltage, that is proportional to the muscle contraction. The mecahnoelectrical transducer consitsts either of a linear potentiometer or a strain gage transducer (shown in figure 4).

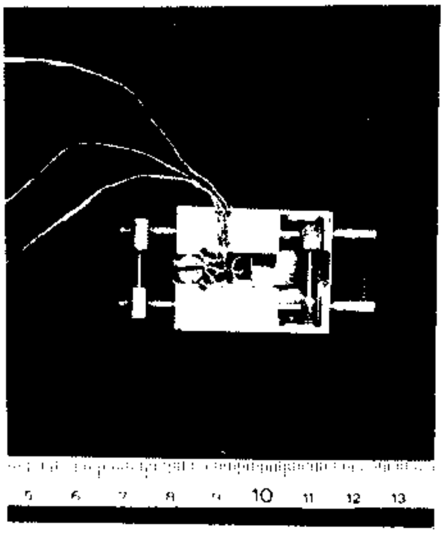

Figure 4

The maximal force has 4 kp, the way about 5 mm. By using another sprin with more or less stiffness the necessary force can be adjusted to the individual conditions. The mechanoelectrical transducer may always be used, it the mechanical operation is not possible or to heavy. The transdurcers and the external powered system can also be applied to patients with muscle cannels.

Application

The application of the circuit is demonstrated by a forearm amputee and an EMG preamplifier. The figures 5 and 6 show the stump.

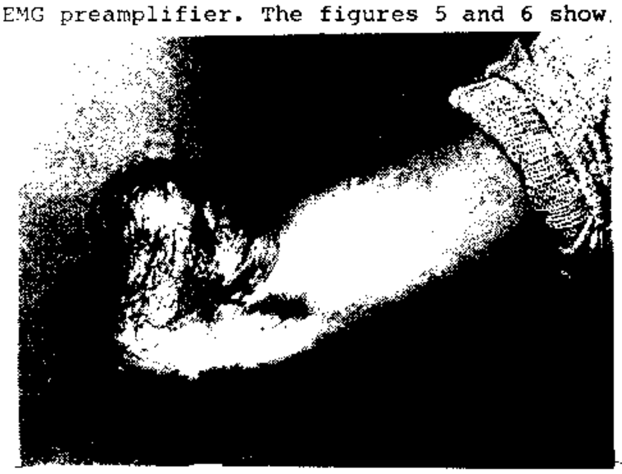

Figure 5

Figure 6

Coursed by an accident nearly the whole forearm was amputated. The only availeble EMG source in the forearm is the flexor muscl. The figure 7 shows the whole prosthesis and figure 8 the electronical equipment.

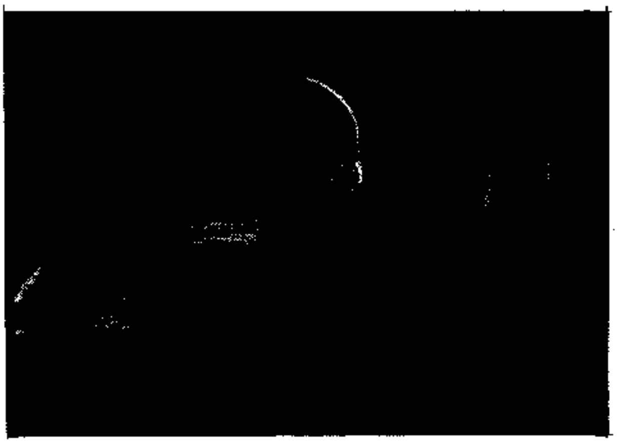

Figure 7

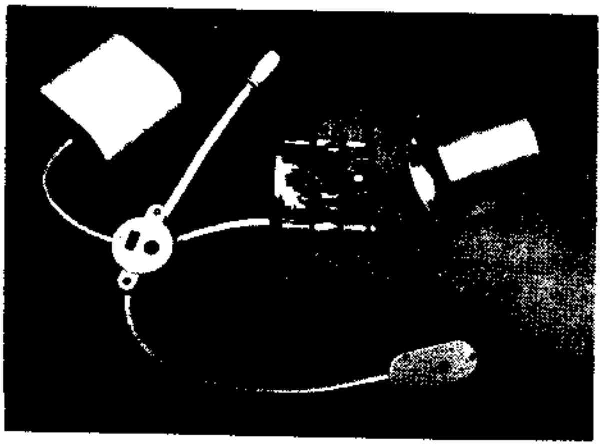

Figure 8

We did not use any cable outside the prosthesis. The necessary battery has a voltage of 12 V and 225 mAh.

Figure 9

The patient learnt to work with the prosthesis very quickly. To check whether the hand, i. e. the whole circuit, is used, we built an electronical counter into the prosthesis developed at our institut by Dipl.-Ing. H. v. Nettelhorst. The counter has a size of 13,5 mm·Ø x 31 mm. It is able to count about 2,1 Mill. steps. So it is possible for us to check whether the prosthesis is really used or not. If it is not used we can question why and try to improve the system.

References

[1] Nietert, M., Maas, R.: Neue mechano-elektrische Bausteine für die Steuerung von fremdkraftbetätigten Hand- und Armprothesen
Z. Biomedizinische Technik 18 (1973)

[2] Maas, R.: Ein neuer Entwicklungsschritt auf dem Gebiet myoelektrischer Steuerungen von Oberarmprothesen
Z. Orthopädie-Technik 8 (1973) pp 261 - 263

[3] Roesler, H.: Einfache Messungen der Dynamik der natürlichen Hand
Z. Medizinische Technik 20 (1968)

[4] Straube, V.: Erfahrungen bei der Versorgung Unterarmamputierter mit elektromechanischen Fremdkraftprothesen
Z. Orthopädie-Technik 9 (1972) pp 253 - 256

[5] Schmidl, H.: Versorgungsmöglichkeiten und der konstruktive Aufbau von myoelektrischen Prothesen für Unterarm- und Oberarmamputierte
Z. Orthopädie-Technik 9 (1969) pp 237 - 241

Name of author:

Dipl.-Ing. H.-P. Steffens
1 Berlin 12, Straße des 17. Juni 135

References

[1] Nietert, M., Maas, R.: Neue mechano-elektrische Bausteine für die Steuerung von fremdkraftbetätigten Hand- und Armprothesen
Z. Biomedizinische Technik 18 (1973)

[2] Maas, R.: Ein neuer Entwicklungsschritt auf dem Gebiet myoelektrischer Steuerungen von Oberarmprothesen
Z. Orthopädie-Technik 8 (1973) pp 261 - 263

[3] Roesler, H.: Einfache Messungen der Dynamik der natürlichen Hand
Z. Medizinische Technik 20 (1968)

[4] Straube, V.: Erfahrungen bei der Versorgung Unterarmamputierter mit elektromechanischen Fremdkraftprothesen
Z. Orthopädie-Technik 9 (1972) pp 253 - 256

[5] Schmidl, H.: Versorgungsmöglichkeiten und der konstruktive Aufbau von myoelektrischen Prothesen für Unterarm- und Oberarmamputierte
Z. Orthopädie-Technik 9 (1969) pp 237 - 241

Name of author:

Dipl.-Ing. H.-P. Steffens
1 Berlin 12, Straße des 17. Juni 135