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Monash Rehabilitation Technology Research Unit

Visual Feedback For A Myoelectric Hand Prosthesis

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BACKGROUND:
Development of motorised upper extremity prostheses and control systems has been very successful , however the same can not be said for the development of feedback systems. The lack of feedback in powered prostheses makes control difficult, particularly outside the field of vision. While sensory feedback is required for better overall control and perception, less complicated systems would still be useful, such as visual or audio feedback. In considering the more basic methods of feedback the same things are still important, that is simplicity, reliability and maintaining prosthesis self containment.

People using myoelectric hands are often frustrated by not knowing why they cannot get the prostheses to do what they wish. There are numerous reasons for a hand not functioning properly, these range from incorrect muscle contraction or a flat battery to broken wires inside the hand. A simple feedback system could relieve some of this frustration and help the user learn how to control the hand better.

PURPOSE:
The purpose of this project was to develop a simple feedback system for use with a myoelectric controlled hand prostheses. The unit would be required to show basic conditions that were felt to be important for both the user and clinicians. Such a device would be helpful in training and general use of a myoelectric hand, through helping to determine the possible cause of problems with control.

REQUIREMENTS:
Discussions with therapists, prosthetists and engineers determined the most important requirements of the unit, in both the technical and clinical sense, to be as follows;

Clinical
-indication of which muscle group is contracting
-indication of contraction isolation
-indication of strength of contraction
-indication of electrode contact with skin
-indication of grip strength
-"on/off" indication.
-ease of use
-no interference with normal function.

Technical
-indication of battery charge
-indication of function of hand
-integration with existing components
-low power consumption
-light weight
-suitable size (to maintain self containment of prostheses).

RESULTS:

Investigation into the function of the hand and how the requirements could be achieved, showed that a number of them were outside the scope of the project or could not be realised within the time allowed. One of these was indicating electrode contact, it was decided that this was outside the scope of the project at this stage.

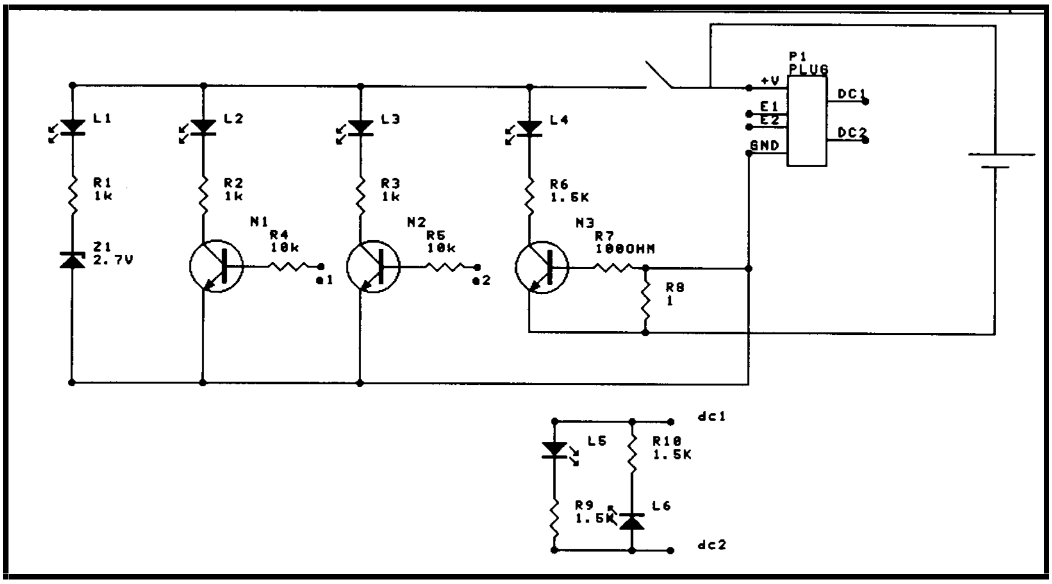
Physical difficulties also prevented some requirements being achieved, such as "on/off" indication. The design of the switch prevented good contact being made without great difficulty, and there was no other place that this function could be monitored.

Indication of strength of contraction was left at the level of the electrodes which have variable input sensitivity <20uV. This meant that as long as the contraction was greater than the threshold set on the electrode, the feedback system would show that the electrode had been stimulated. Further feedback from this area was thought to be too detailed and too confusing for the type of display that was to be used.

The other requirements were met and are described below.

Battery Charge;
The hand is rated as having an operating voltage of 6V but can function at voltages as low as 4.9V. This meant that the voltage level that was chosen to indicate low charge had to be greater than this minimum voltage, 5.1V was chosen as the cut off.

The battery charge was detected in parallel to the power input to the relay/switch. The circuit used to detect the battery charge is shown in the circuit diagram below. The LED remains "on" while there is a voltage greater than 5.1V, and switches "off" if the voltage is less than this. Due to the characteristics of the LED the light emitted dims as the voltage gets close to the cut off. This allows the user to recognise that the battery will need charging, before it is actually dead.



Electrodes:

When isolated muscle contraction sufficient to stimulate the electrode occurs, the electrode outputs a digital signal, with zero low and approximately 6V high. The signal is sent to the relay on channel one of the electrode lead.

The large difference between the high and low voltage allowed a simple switching circuit to be used, which did not require an accurate switching threshold, to indicating electrode output. This display would be particularly useful during training as it gives instant feedback on whether correct muscle contraction had occurred.

Open/Close:

The output from the relay to the motor carries positive or negative 6V depending on the direction of drive. The active and common lines were sampled and used to drive forward and reverse biased LEDs. When the hand was opening (+6V) the forward bias LED was turned on, and when the hand was closing the reverse bias LED was turned on.

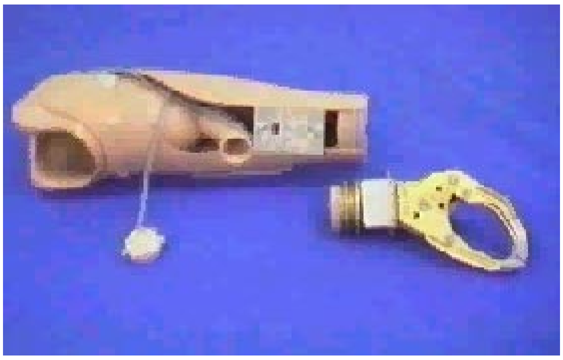
This gave an indication of correct function of the hand, from electrode to motor, thus this would be more useful to the clinician than the patient, but the user could still gain from it.

Full extension/grip:

When the hand is fully extended, fully closed or gripping an object the motor will continue to attempt to drive the hand as long as electrode stimulation is maintained. This results in increased current being drawn from the battery. The average operating current is ~180mA, but when the hand is in the extreme position and continues to try to drive, the current increases to ~700mA.

A simple switching transistor circuit was placed in series with the common line between the relay and the battery. The increased current flow induced a voltage drop across R? great enough to switch the transistor into active mode and thus power the LED, indicating that the hand was at full extension, fully closed or gripping an object.

The lay out of the unit was designed as shown below. This was felt to be the easiest to use and the most logical, with the displays in positions corresponding to their origin, and related to those closest to them. A switch for the feedback system was included because it was felt that the patient may not wish to have the display working every time they use their hand. The switch was placed in the circuit so that the hand could still be used without the feedback system switched "on". The unit was designed to be placed midway up the forearm on the medial side. This position gives easiest viewing during most activities.



CONCLUSION:

The unit was designed so that when a patient puts on their myoelectric hand and cannot get it to work, they can look at the LED display and use it like a check list to narrow down the source of the problem. Is the battery charged? Is the electrode giving an output signal? If not try concentrating on the muscle contraction. Is the signal from the electrode reaching the motor? If I cannot open the hand further, is it because it is already fully extended?

The current working model successfully shows the required outputs, but still could be improved greatly. Although low current LEDs were used and other consideration made to reduce power consumption, further circuit design aimed specifically at reducing the power required would improve the unit greatly.

More appropriate shape and reduced size are required for the system to be functional in a real situation. One option that could be considered to reduce size would be to use a microprocessor to control the unit. However the power requirements of the microprocessor would have to be considered.

Development of connectors that would allow the system to be installed and removed easily and leave the hand as normal, also needs to occur before the system could be used regularly. Adaptors for other models and systems should also be investigated, so that use of the feedback system was not limited to this particular model.

As well as the areas already mentioned, further development would be achieved with patient trials. The users opinion would be very important and could raise issues not thought of, by the clinical team.

Overall the project should be viewed as a success and development in the area should be continued, as it could be of great assistance to both the patient and the clinician.

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