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NEW DEVELOPMENTS IN THE VARIGRIP® LINE OF CONTROLS INCLUDING A NO-SLIP® VARIGRIP

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INTRODUCTION

A number of new concepts for hand control were introduced at the 1993 Myo-Electric Control Symposium [1]. This year many of those ideas are available commercially. In addition new concepts have been reduced to practice so that they can be reported here.

REVIEW OF PRODUCTS DESIGNED FOR LIBERTY TECHNOLOGY

Better hands are continuing to drive the market for controls. During the past year the Liberty Technology VariGrip® control unit has been upgraded to include two features discussed last year. The VG01 controllers for use inside Otto Bock hands now include a battery saver circuit that operates in both directions. In addition there is a one-site capability.

One-Site Control

For many years Otto Bock have offered a one-site, two-channel hand, their 8E25. It achieves one-site control by sampling the initial signal from the myoelectrode. If this signal rises quickly, the hand opens; if slowly, it closes. The new VariGrip controls borrow from this concept but with several improvements. If the *open* and *close* input lines are connected together, the VariGrip turns into a one-site controller. It does this by looking at both inputs for 58 msec when a signal first appears. The circuit has two thresholds. If the input stays between the two thresholds for the entire 58 msec, the circuit commands that the hand *close*. If at any time during the 58 msec the second threshold is exceeded, *open* is commanded. Once *open* or *close* have been selected the speed and grip are controlled in the usual way by varying the strength of the input. Once a direction is selected it is locked on until the input signal drops below the lowest threshold. The 58 msec is a very short time so it does not interfere with the user's ability to control speed. Typically speed is controlled over a period of a half second to several seconds. There is no conflict with the use of VariGrip for two-site control because in two-site control only one signal at a time is being generated.

Battery Saver Circuits are Added

The VG01 In-hand VariGrip now incorporates a battery saver on both *open* and *close*. The saver works by integrating the total charge delivered during an *open* or *close* cycle. This is better than a simple timer for a variable speed controller. A battery saver is not appropriate with a Bock Greifer. But then the Greifer needs an In-Wrist unit in any case, and here the save can be disabled.

VariGrip Works with Myo, Touch or Linear Potentiometer Signals

There is nothing special about the Bock 13E125 Electrode or the Steeper SC01. These units simply generate a varying voltage. Any other input device that can vary the voltage will work just as well. One or two pressure pads (Liberty Technology TP01) will substitute for one or two electrodes. Two channel control with one pad is very easy to learn. For one-site control a linear potentiometer (ETI LCP8S-10-50K) can be used to generate a voltage as the transducer is moved over a distance of 7/16" (10mm). This is also easy to control.

Other New Liberty Controllers

Three other designs have recently been made available from Maryland Electrolimb for production by Liberty Technology. First there is the VG21 a circuit produced solely for the Steeper line of powered hands. This circuit has been optimized for the high-speed motor in the new Steeper hands. It has also been made to fit both left and right hands of all sizes and it works with both Steeper and Otto Bock myoelectrode amplifiers. In addition a circuit is being developed to fit into the Centri UltraLite hand. This circuit must handle the Centri hand's extra brake motor. Finally, an In-Wrist VariGrip has been developed which can be used in pairs to control two functions with two muscles or signal sources in whichever mode is easiest for the user - one muscle for each degree of freedom or slow contraction for one degree of freedom, e.g. hand function, and fast contraction for a second, e.g. wrist rotation.

DEVELOPING A NO-SLIP® VARIGRIP®

Background

Prosthetic hands are notorious for dropping things. One solution to this problem would be to give the user some sort of feedback so that the grip force could be monitored. In fact this was tried more than 14 years ago [2]. However, such feedback will only assist in getting the initial grip force correct. There are two many time delays in the myocontrol loop for the user to adjust to slippage which is the important problem.

Measuring grip

The best analog for grip that is available is the pressure measured on one or more gripping surfaces. At least a decade ago UNB introduced a system using stain gages to detect finger deflection, but these proved hard to install and relatively easy to destroy. The modern Force Sensing Resistor (FSR) is a more convenient sensor of grip force. It is easy to install a strip of FSR by removing a portion of the plastic thumb or index finger and inlaying the strip which is then covered with a silicone finger pad and the protective glove.

How the No-Slip Circuit Works

With No-Slip the user grips an object with what seems to be an appropriate force. The No-Slip circuit "remembers" the grip force that the user selects and thereafter it activates the motor any time it detects a reduction in force. This ability is particularly useful when moving heavy, hard objects which tend to shift in the hand since the gravitational vector changes during lifting and positioning. The circuit must reposition the fingers in 50 msec if slip is to be limited to 1 to 2 cm. Only an electronic circuit can respond fast enough to maintain grasp when an object begins to slip due to changes in position as the object is manipulated in space.

Avoiding Slippage

What should a no-slip system do? Listed below are the design criteria for the no-slip circuit. As in most engineering assignments, getting these criteria right is at least as important as solving the problem afterwards. The critical insight is that the hand control circuit must work autonomously like a spinal reflex.

DESIGN CRITERIA FOR NO-SLIP CIRCUIT

1. Grip force will be monitored by a pressure pad buried under a compliant finger pad. (The pressure pads are InterLink Electronics FSR Line of Force Sensing Resistors)
2. The circuit will retain the value of force as measured by the pad whenever the *close-hand* command ceases.
3. After the close-hand command ceases, the circuit will compare the retained pressure value and the actual value and create a difference signal.
4. A difference in the direction of increased force will be ignored, but a difference resulting from less force will generate an internal *close-hand* signal proportional to the difference that will drive the hand further closed.
5. While no time-constant criteria are called out *a priori*, suitable time constants, deadbands and so on will be explored during the development of the ultimate circuit.
6. The circuit shall fit into the same small space now used for VariGrip circuits.
7. The No-Slip feature will not engage when the hand stops with no pinch or due to the normal pressure exerted by the protective glove.
8. The quiescent drain of the circuit will be less than 1 mA.
9. A battery saver will engage when the hand opens fully. This feature is not required for closure

because the No-Slip circuit will accomplish the same thing.

Finger Design

While in the past, hard solid plastic fingers have been a disadvantage, they are ideal for conversion to force measuring fingers. About 1/3 of the thickness of a finger is removed by creating a flat surface for a strip of FSR material. This strip is then covered with a half round piece of material with rubber like properties. Selection of the right material will not only prolong the life of the strip of FSR it will also make holding objects such as a round pencil much more secure.

Time to Market

This product is now ready for demonstration. Getting it ready for full production will probably take about a year.

REFERENCES

1. Dillon, S.S., (1993) "*Variable Speed Control of Terminal Devices*", Proceedings of the Myoelectric Control Seminar, University of New Brunswick, Canada.
2. Scott, R.N., Brittain, R.H., Caldwell, R.R., Cameron, A.B., Dunfield, V.A., (1980) "*Sensory Feedback System Compatible with Myoelectric Control*", Medical & Biological Engineering & Computing, V. 18, pp. 65-69.