From "MEC '02 The Next Generation," Proceedings of the 2002 MyoElectric Controls/Powered Prosthetics Symposium
Fredericton, New Brunswick, Canada: August 21–23, 2002. Copyright University of New Brunswick.

MICROPROCESSOR CONTROL FEATURES

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The very Underlying Principle of Control for the Otto Bock Myoelectric System is "Muscle contraction should lead to function." If you think about picking up an object with your sound hand, you simply pick up the object. An amputee must concentrate on more activities than that of an individual with a sound hand. If an amputee wears a prosthesis they must first open their hand, then position their hand over the object, then close their hand around the object and finally determine how much grip force should be applied to the object. With all of those things to consider, the relationship between their input signal (EMG) and the output of the hand (motor speed or grip force) must remain constant to minimize the learning curve. If the relationship is variable, the patient must relearn how to control the hand depending on the variables and thus control can be very unpredictable. The analogy is getting into someone's car that just had a brake job done. You are used to putting high pressure on the pedal in your car in order to slow the car down so when you touch the pedal in the other car, it brakes very abruptly. You need to relearn the relationship between pedal pressure and braking speed. This is something we need to avoid in myoelectric fittings. Therefore, the microprocessor control in the Otto Bock system contains features to minimize the effects of outside influences. The outside influences include the following:

Opening position:

As the glove is stretched while the hand is opening, resistance to the motor is increased and without intervention would cause the hand to slow down.

Battery Voltage:

In the morning when the battery is fully charged, the hand runs at full speed. During the day the voltage of the battery slowly drops off and without intervention would cause the motor to run slower with the same signal (EMG) from the amputee.

Temperature:

Colder temperatures produce higher resistances to the motor than if the temperature were warmer. Without intervention the cold temperature could make the hand run slower.

Aging glove:

If a glove or inner hand shell is old and stiff, this again will produce high resistance to the motor. Without intervention the motor would run slower with an old stiff glove than with a new flexible glove.

Normal wear and tear:

As mechanical parts wear out they run less efficient putting higher resistance on the motor. Without intervention this would cause the motor to run slower.

Slipping objects:
If an object's center of gravity or mass changes it could potentially slip out of the prosthetic hand. This would be potentially a problem when filling a glass with water where the held glass is in the prosthetic hand for example.

Crossover signal:
With other systems crossover signal, co-contraction is a very difficult problem to overcome. If the two signals necessary to run two site myoelectric systems are continually influencing each other, the patient is constantly seeing different results in function for the same muscle contraction.

Electro-magnetic disturbances:
While working in some environments, Electro-magnetic noise coming from some electrical sources can cause intermittent functional problems within the hand. Without intervention it would be impossible for the amputee to control the hand and have to avoid exposure to these environments.

Weak signals:
Weak signals can jump up and down erratically and cross the "ON" threshold many times while performing a singular function. Without intervention, this would cause the function to be jumpy and erratic as well.

The Otto Bock microprocessor has features that minimize the affects of these variables so the amputee can learn the control relationship once and the hand takes over from there to maintain that relationship. The microprocessor features are as follows:

Closed loop control:
Motor speed is constantly evaluated to make sure that the same input signal (EMG) produces the same output (motor speed or grip force) no matter the variables. Muscle contraction equals function and the function should always be the same. An analogy would be cruise control in a car. Old technology: the cruise control set a fixed pedal position and if the car went up or down a hill it would either slow down or speed up because it didn't vary the power to the motor. New technology: cruise control sets the speed of the car and varies the pedal position to maintain a constant speed whether going up hill or down hill. In myoelectrics, Otto Bock microprocessor technology varies the power to the motor to make the speed constant with the same EMG signal. In proportional DMC control this is especially important. If the amputee generates a high signal the hand should always run at the same high speed. If the amputee generates a small signal the hand should always run at the same slow speed. Patient benefit is that the hand is predictable and consistent.

Proportional Grip Force:
The question is "Proportional to what?" Otto Bock Microprocessor technology produces a unique relationship for grip force and signal strength. The strength of the grip force is proportional to the strength of the muscle contraction. No other manufacturer has done this. Patient benefit is that this relationship is constant and more physiological and therefore easy to learn and understand. A relationship that remains constant can be learned and thereby produce proprioception. Also while holding fragile objects; the grip force is not increased by small inadvertent signals above the on threshold.

Auto Grasp:

This feature is found only in the sensor hand. In the human hand, when an object in the hand gets heavier, the Autonomic nervous system response is to increase grip force to keep the object from slipping away. The Sensor technology in the hand is designed to mimic this response. Patient benefit is that when holding objects that change weight such as the case when filling a glass with water, the hand automatically grips harder to prevent the object from slipping away.

First signal wins:

Two signals are used to open and close a typical myoelectric hand. The first signal to cross the "ON" threshold will win over the other signal. Patient benefit is that even in situations of crossover signal or some refer to it as co-contraction, they can still have smooth proportional control over their hand. The speed is not influenced by the difference between the two contractions.

Virtual ground:

The operational range of the control of the hand is adjusted automatically inside the control circuit in situations where there might be Electro-magnetic disturbances present in the system. Patient benefit is that they can control their hand even in areas where there are Electro-magnetic disturbances such as would be found around some electronic systems like TV's or fluorescent lights.

Different "ON" and "OFF" thresholds:

The "ON" threshold is fixed at .54V output from the electrode and the "OFF" threshold is fixed at .35V output from the electrode. While EMG is an appropriate signal to control a myoelectric device, it can be rather jumpy in nature. To run a hand slowly requires a small EMG signal. If the "ON" and "OFF" thresholds were the same, the EMG might jump up and down crossing the threshold many times causing a pulsation of the hand while it is running slowly. Separating the thresholds benefits the patient by allowing for smooth control over a slowly moving hand.

To summarize, Otto Bock microprocessor technology is appropriate technology to maintain the ideal that muscle contraction should lead to function and therefore produces many patient benefits. In the end the patient is not bothered with the details of how the hand works, they just know that it does.