Microprocessor-Controlled Prosthetic Leg

HIGH-TECH SOLUTIONS DELIVER IMPROVED QUALITY OF LIFE

Lightweight DC micromotors, combined with intelligent control technology, offer the chance to walk in a way that feels very similar to natural movement.

When it comes to finding technological ways of dealing with the loss of a limb, as, for example, the result of the amputation of a leg, two key things need to be taken into account. Firstly, it took nature a long time to develop the perfect "apparatus" to allow humans to move around. Secondly, people are creatures of habit—they tend to carry on moving in the way they're used to. All the solutions which have been tried to date, from wooden legs to high-tech prostheses using state-of-the-art materials, have worked in a purely passive way. Something that these devices all have in common is that their function doesn't change during movement. Now, however, a new solution has been developed around the use of microprocessor-controlled prostheses. Just like natural limbs, these can react automatically, adapting to the current situation.

Lightweight DC micromotors, combined with intelligent control technology, offer the chance to walk in a way that feels very similar to natural movement—providing clear benefits for users in terms of both safety and comfort.

A prosthesis is always a complex medical device which needs to be adapted to suit the individual. Technical components, however, can only be manufactured economically on a large scale. It was thus clear to prosthesis specialist Otto Bock from Vienna that a new, advanced prosthesis would need both to be suitable for use on a global scale and to offer top performance under all possible conditions.

His solution was to develop a so-called active prosthesis, whose success is based on the reliable and smooth interaction of mechanics, electronics and the user. To achieve this, the prosthesis specialist called in the micromotor experts from Faulhaber. Faulhaber's many years of experience with DC micromotors translated into a reliable, custom made motor solution for the high-tech Bock prostheses.

Following Nature's Lead

After leaving the factory, each prosthesis is fine-tuned by the local orthopedic specialist to suit the individual user. This is now standard practice with high-quality prostheses. What's special about this device, however, is that it uses its electromechanical systems to adapt to the individual's walking style and create a truly natural feeling for the user. Walking is not just a matter of putting one foot in front of the other; therefore, simply "improving" on a wooden leg by adding a hinge to act as the knee is not an option. Nature uses tendons and muscles to provide damping and adapt limb movement with each individual step; hence, people are able to make optimal use of their weight and force—whatever the conditions and depending on whether they are walking, running, cycling or standing.

Finding a way to simulate this natural damping requires great attention to be paid to the mechanics and electronics. Thanks to modern high-power microprocessors, miniature precision sensors and micromechanical motors, the technology now exists to achieve very impressive results. Compact prosthetic technology allows the user to walk slowly or fast, run, climb slopes or cycle—without needing to pay much special attention to what the limb is doing. In addition, the fact that the knee joint can react immediately to changes in speed or surface conditions improves safety considerably. Even in the case of a stumble, the real-time electronics will reliably prevent the prosthesis from buckling. Over the long term, the ability of the prosthesis to react intelligently safeguards the health of the user, avoiding undue wear and tear on the other joints or problems arising from poor posture and thus overstraining of the healthy leg.

A Practical Solution

Natural movement can only be achieved by the prosthesis reacting in a highly accurate and subtle way to the changes that occur with every step. In order to ensure that this occurs, highly sensitive sensors provide reports on the current situation and stresses 50 times per second. A knee angle sensor provides information used for dynamic control, while load sensors in the lower leg measure the pressures at the heel and front part of the foot. A high-power processor then analyzes these results and passes on appropriate instructions to the damping mechanism.

Hydraulic damping has proved to be of particular value. This allows the appropriate damping values to be implemented quickly and accurately. Prosthesis specialists make use of proven technology for the interface between the electronics and the damping mechanism: easy to control miniature DC motors. These micromotors, equipped with precious metal brushes, offer high performance in combination with a slim design. The high efficiency of their motors means that prostheses can work without needing recharging for periods of up to two days, even with the limited capacities of lithium batteries. In the current example, the high-performance 10 mm motors function via friction gears in a planetary set. This serves to adjust the actual damping valve. With each step, the damping is adjusted from its maximum level to almost zero and then back again.

Durability Reigns Supreme

All components need to be able to stand up to years of continuous use. This is no problem for the precious metal miniature DC motors deployed within this area. Use of the prostheses around the globe places considerable demands on the technology, which must be able to cope with temperatures ranging from –15 degrees C to +65 degrees C. It must also be able to function without problems in all climates, from dry to wet, and withstand salty air or desert sand. With this in mind, all relevant components are sealed, with some being additionally housed within an extra casing.

Despite the use of robust and sealed components, as with all medical devices, provision must be made for the possibility of the failure of all and any components, including, for example, a drained battery. In such a case, the prosthesis will automatically provide maximum damping, in effect functioning as a wooden leg and thus providing the maximum possible level of safety. The wearer is thus always able

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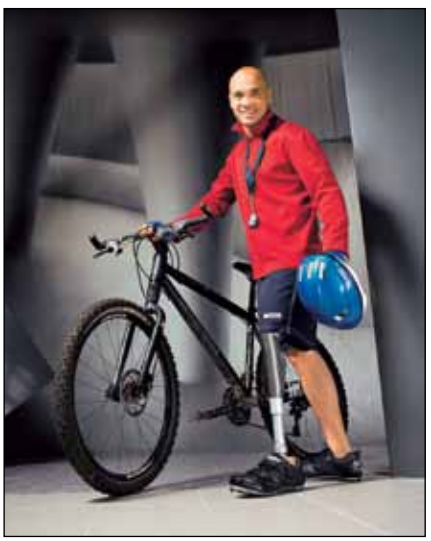
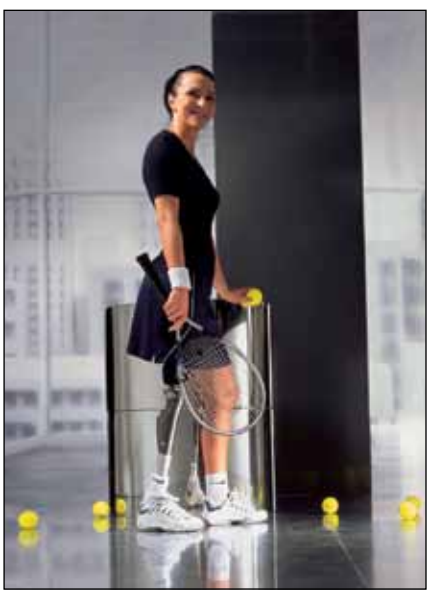
A new mechanical prosthesis from Otto Bock of Vienna allows more natural movement for patients.



Individual movement programs can be set for different activities.



Walking, running, sprinting and cycling are made possible once again.

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to continue walking, albeit at a lower level of comfort. All levels of damping between virtually zero and the highest level can be individually set by a certified orthopedic technician, using the *C-Soft* software. The user is also able to choose between two settings—for example, one optimized for walking and one for cycling. The former would use active stance phase damping to allow easier standing and walking, while this would be switched off when cycling. The prosthesis can also be set for inline skating, cross-country skiing or many other activities.

The combination of modern electronics with robust, high-performance miniature DC motors provides an enormous improvement to the comfort of those using prostheses. Dynamic motors, real-time electronics and high resolution sensors mean that it is now possible to fit all the components required for natural movement into the limited space provided by a prosthesis.

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