Single channel hybrid FES gait system utilizing fluid power

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A new system for gait restoration by electrical stimulation is presented. The system combines electrical stimulation of the paralyzed quadriceps muscle with a hip-knee orthosis. The orthosis is spring-loaded and contains pneumatic components that stores and transfers the energy from knee extension caused by quadriceps stimulation to a pneumatic actuator that drives hip motion. In this manner, cyclic hip and knee motion with arbitrary timing can be achieved using a single channel of surface stimulation.

The hip-knee orthosis with pneumatic fluid power components is called Energy Storing Orthosis (ESO). ESO utilizes two double acting 7/8 inch bore pneumatic cylinders, one for each joint. During knee extension, the cylinder compresses air in Teflon tubing which acts as an accumulator. To control knee extension trajectory the system uses a 2 way 2 position pneumatic proportional valve. To control hip extension, ESO uses a 3 way 2 position spring offset solenoid actuated pneumatic valve. The compressed air when released into the hip cylinder assists the subject in forward progression. The springs assist the system in coming back to the equilibrium position, which is the start of the step. An exhaust valve mounted on the knee cylinder helps the cylinder extend without creating vacuum.

The main challenge in developing this system has been designing and selecting miniature fluid power components. The objective driving the design of fluid power for orthosis application has been minimizing size and weight of the components and energy lost in transfer from one joint to another. A study was carried out to analyze feasibility of hydraulic system but not pursued due to high orifice losses in valves.

Previous work developed a dynamic model and bench top prototype of the energy storing system. Simulation and design prototypes will be presented towards developing a wearable version of the complete gait restoration system.