

An Electro-Magnetic Cell Stimulator

Authors: Hatem Rizk, Cheng L. Mo, Walter D. Leon-Salas, Todd Hall, Michael Wacker and Marco Brotto

Author organizations: Hatem Rizk and Walter Leon-Salas are with the UMKC School of Computing and Engineering. Cheng L. Mo is with the UMKC School of Pharmacy, Todd Hall, Michael Wacker and Marco Brotto are with the UMKC School of Nursing

Abstract: A device to stimulate bone and muscle cell growth and possibly for treatment of bone and muscle injuries is presented. The device, called EStim, generates electric and magnetic pulses at programmable intervals. This device will also be used to study the crosstalk between bone and muscle cell growth. In a human or animal body, muscles and bones are intimately interrelated and the loss of activity in one of them affects the other. This interrelation is especially evident in persons with bone fractures. While the bone is healing, the muscles loose mass due to lack of exercise. Furthermore, when skeletal muscles are not exercised, bone mass decreases. In these situations, muscle mass can be partially maintained if externally stimulated by applying repetitive electric pulses. The EStim has been designed to generate electric pulses of different frequencies and amplitudes to stimulate muscle growth. It also generates magnetic pulses to stimulate bone growth. This dual stimulation is a unique feature of the EStim and makes it a promising device in the treatment of bone fractures or for muscle stimulation. Besides this clinical application, the EStim is being used to study the crosstalk at the cellular level between muscle and bone cells. A line of C2C12

cells is being used to test the effects of the electric and magnetic pulses on cell growth. Variables such as pulse repetition, field strength and rest period duration have been evaluated. Initial results show that electric stimulation induces cell hypertrophy similar to the ones observed in heat shock experiments (see abstract by Romero et al).

The EStim device consists of three sections: the controller, the high-voltage generation unit and the high-current generation unit. The controller is built around the MSP430 low-power microcontroller. It handles communication with a host computer to change settings or to perform tests. Settings such as pulse repetition, pulse width, number of pulses, rest time between pulses, and magnetic field strength can be changed by the user. The controller also monitors the battery voltage and the maximum pulse current. As a safety measure, pulse generation is stopped if the current through the probe exceeds a preset value. The high-voltage generation unit consists of a boost converter that is able to generate voltages up to 40 V and an H-bridge that allows the generation of biphasic or monophasic electric pulses. The high-current unit consists of a buck converter able to generate currents up to 10 A. These large currents are used to generate magnetic fields of up to 10 mT. This device will be used to better understand the interplay between bones and muscles. Ultimately, our goal is test this device in animals and humans to fully realize its applications on musculoskeletal injuries and diseases.

Keywords: Magnetic stimulation, electric stimulation, bone-muscle crosstalk.