

# Mathematical Model and Apparatus to Optimize Functional Electrical Stimulation for Non-Isometric Limb Movement

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## ABSTRACT

Researchers at the University of California, Davis have developed a mathematical model and apparatus capable of identifying optimal stimulation patterns to improve limb motion during functional electrical stimulation.

## FULL DESCRIPTION

Functional electrical stimulation (FES) uses electrical currents to induce contractions in muscles and is used in therapy to restore functional movement in extremities affected by paralysis. Mathematical muscle models could help optimize stimulation patterns used by commercially available FES systems but the current mathematical models are limited to isometric conditions and a narrow range of stimulation patterns.

A Researcher at the University of California, Davis, working in cooperation with Researchers at the University of Delaware, have developed a method and apparatus capable of identifying optimal stimulation patterns that can be used to produce non-isometric functional movements. This method identifies the interpulse intervals and pulse intensities that should be used during FES to allow for more precise limb motion control and reduce muscle fatigue, improving the overall effectiveness and efficiency of FES.

## APPLICATIONS

- ▶ Feedforward and feedback limb control systems
- ▶ Functional electrical stimulation
- ▶ Real-time, non-isometric skeletal-muscle movement modeling

## FEATURES/BENEFITS

- ▶ Can be used in real time
- ▶ Non-isometric movement modeling
- ▶ Reduced muscle fatigue
- ▶ More precise limb control
- ▶ Optimized FES stimulation pattern

## RELATED MATERIALS

- ▶ [Maladen RD, Perumal R, Wexler AS and Binder-Macleod SA. 2007. Effects of activation pattern on nonisometric human skeletal muscle performance. J Appl Physiol. 102\(5\):1985-91.](#)

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## INVENTORS

- ▶ Wexler, Anthony S.

## OTHER INFORMATION

### KEYWORDS

functional electrical  
stimulation, FES,  
mathematical movement  
model, non-isometric,  
movement, limb motion,  
paralysis, stimulation  
pattern

### CATEGORIZED AS

- ▶ **Imaging**
- ▶ Other
- ▶ **Medical**
- ▶ Devices
- ▶ Therapeutics

### RELATED CASES

2005-449-0

► Ding J, Lee SC, Johnston TE, Wexler AS, Scott WB and Binder-Macleod SA. 2005. Mathematical model that predicts isometric muscle forces for individuals with spinal cord injuries. Muscle Nerve. 31(6):702-12.

► Chou LW, Ding J, Wexler AS and Binder-Macleod SA. 2005. Predicting optimal electrical stimulation for repetitive human muscle activation. J Electromyogr Kinesiol. 15(3):300-9.

► Ding J, Wexler AS and Binder-Macleod SA. 2003. Mathematical models for fatigue minimization during functional electrical stimulation. J Electromyogr Kinesiol. 13(6):575-88.

► Ding J, Wexler AS and Binder-Macleod SA. 2002. A mathematical model that predicts the force-frequency relationship of human skeletal muscle. Muscle Nerve. 26(4):477-85.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	8,140,166	03/20/2012	2005-449

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

► Biomimetic Chemical Compounds for Capturing Carbon Dioxide from Power Plant Stacks and the Atmosphere

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