# T01: EMG modeling

## A MODEL OF ELECTRICAL STIMULATION

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**AIMS:** To develop a mathematical model and analytical solution for a problem of muscle electrical stimulation inducing muscle contraction. Two models of the volume conductor have been considered. 1) A planar, two tissue, grounded model, constituted by fat and muscle tissues, with a fat layer placed both over the muscle and below; the stimulation current is delivered over the first fat surface, the second fat surface is grounded. 2) A planar, three layer model, with skin, fat and muscle tissues, with stimulation current delivered over the skin surface and no grounded surface (it is only assumed that the potential vanishes at infinity).

**METHODS:** Two planar, multi-layer (skin, fat, muscle), an-isotropic models of a physiological tissue (referred to as volume conductor) are studied. Both conductivity and permittivity of the volume conductor are considered, dispersion is neglected. The analytical solution is obtained in the two dimensional Fourier transform domain, transforming in the planes parallel to the volume conductor surface. The model is efficient in terms of computational cost as the solution is analytical (only numerical Fourier inversion is needed). It can provide the current distribution in layers below the skin when an electrical current is delivered at the skin surface.

**RESULTS:** The two models of volume conductor have been compared. Small differences in the current path within the muscle can be observed only close to the grounded fat layer. Thus only the three layer model was further studied. Two representative examples of application of the model have been considered. 1) Simulation of stimulation artifact during transcutaneous electrical stimulation. Only the effect of tissue permittivity is considered, neglecting the other sources of artifact (as the capacitive coupling between the stimulating and recording electrodes). The exponential tail (for a single channel) and the decay of the stimulation artifact (between channels along the muscle fibres) for increasing distance from the stimulation site can be simulated. The effect of different simulated anatomies can be studied (i.e., for different conductivities, permittivities, tissue thickness). Furthermore, the effect of different stimulation waveforms can be simulated. 2) Simulation of interferential therapy. The amplitude modulated current distribution within the muscle was simulated. The model can provide useful indications for the design of optimal stimulation paradigms in interferential therapy.

**CONCLUSIONS:** A mathematical model for the simulation of electrical stimulation inducing muscle contraction is developed. Simulation of stimulation artifact and of interferential therapy are suggested as possible applications. The same solution method could be applied in other fields in which the estimation of the electrical current distribution in a medium induced by the injection of a current from the boundary of the medium is of interest.