**Antenna Model for Myelinated Nerve Fiber**

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### Introduction

- The myelinated nerve fiber with an arbitrary number of Ranvier’s nodes is modeled as a straight thin wire antenna
- Electrode nerve fiber stimulation is taken into account in terms of the current generator \( i_a \), placed at the fiber beginning
- The current generator \( i_a \) represents the nerve fiber stimulation by using the techniques of electro-acupuncture or percutaneous electrical nerve stimulation (PENS), which make use of thin needles inserted through the skin
- The fiber is immersed in the unbounded homogeneous medium defined by conductivity \( \sigma \), relative permittivity \( \epsilon \) and permeability \( \mu \)

#### Current Distribution in the Nerve Fiber

- The current distribution along a straight thin wire is governed by the Pocklington integro-differential equation in the frequency domain [1-3]:

\[
-\frac{1}{j4\pi \mu \epsilon_{eff}} \int_0^\infty \frac{\partial^2 \Phi}{\partial x'^2} g(x,x') \text{d}x' = 0
\]

- \( g(x,x') \) - the lossy medium Green’s function defined as:

\[
g(x,x') = \frac{e^{-\gamma x}}{R}
\]

- \( \gamma \) - the complex propagation constant given by:

\[
\gamma = \left( j\omega \mu \sigma - \omega^2 \mu \epsilon \right)
\]

- \( R \) - a distance from the source to the observation point:

\[
R = \sqrt{(x-x')^2 + a^2}
\]

- \( \epsilon_{eff} \) - the complex permittivity of a medium:

\[
\epsilon_{eff} = \epsilon \epsilon_r - j \frac{\sigma}{\omega}
\]

### Results

#### Passive Nerve Fiber

- Rectangular subthreshold current pulse
- Intracellular current along the fiber, \( t = 1 \) ms, \( L = 2 \) cm
- Intracellular current in the Ranvier’s node 1, \( L = 2 \) cm
- Intracellular current in the Ranvier’s node 2, \( L = 2 \) cm

#### Active Nerve Fiber

- Intracellular current in the Ranvier’s node 3, \( L = 2 \) cm
- Intracellular current in the Ranvier’s node 4, \( L = 2 \) cm
- Intracellular current in the Ranvier’s node 5, \( L = 2 \) cm
- Intracellular current in the Ranvier’s node 6, \( L = 2 \) cm

### Conclusions

- The myelinated nerve fiber is modeled as a perfectly conducting straight thin wire antenna, immersed in an unbounded homogenous medium
- The model is based on the corresponding Pocklington integro-differential equation in the frequency domain, solved by means of the GB-IBEM
- The solution of the corresponding Pocklington equation is related to the intracellular current along the nerve fiber \( i_a \), which is for all cases compared to the CRSS model intracellular current results [4-6]
- The passive Ranvier’s node is modeled by a current source drain representing the ionic current \( I_i \) in each passive node (responses show a rather satisfactory agreement to the CRSS model)
- The active Ranvier’s node is modeled as a thin wire junction with the additional current source, representing the ionic current of the activated node (the results display minor discrepancies in relation to the CRSS model which stem from the approximate modeling of an active state in which the additional current source should represent all the biological effects occurring during the fiber activation)
- The antenna nerve fiber model of a myelinated nerve fiber can provide a theoretical framework for studying a wide variety of stimulus parameters, including wave shape and the amplitude of the excitation pulse
- Thus, the model can be beneficial and versatile tool for interpreting experimental results and studying variables for which there could be difficulties in the laboratory implementation

### References


### Contact

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