OPTIMAL FREQUENCY RANGE FOR ELECTRICAL IMPEDANCE TOMOGRAPHY OF NEURAL ACTIVITY IN PERIPHERAL NERVE

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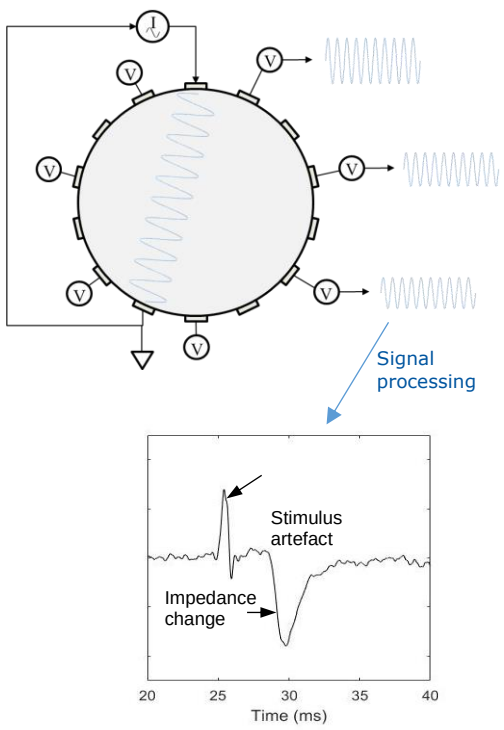
BACKGROUND:

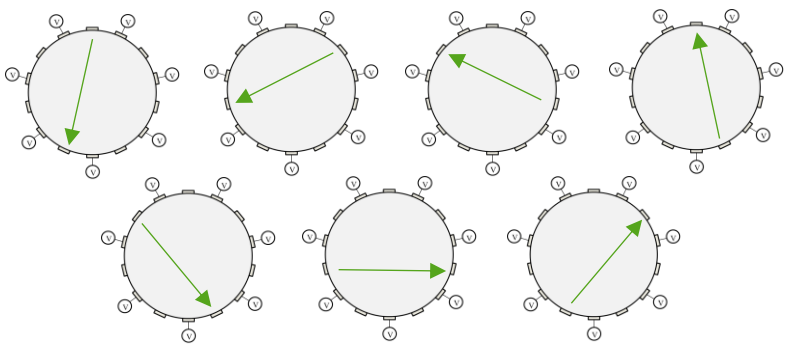
Time division multiplexing in EIT has been demonstrated [1], but is not compatible with real time operation.

Frequency division multiplexing is promising for real time, but is restricted at the upper limit by the frequency roll-off of the electrical impedance in neural tissue, and at the lower limit by the need to avoid the compound action potential (CAP) artefact

OBJECTIVE:

To determine the limits of the operating frequency range for frequency division multiplexed EIT of neural activity in peripheral nerve.





$$\mathbf{g} = \mathbf{A}^{\dagger}\mathbf{v}$$

A = sensitivity matrix
g = conductivity change
v = change in boundary voltage measurements

METHOD:

Lower frequency limit from frequency analysis of CAP using Fourier transform.

Upper frequency limit from impedance frequency roll off:

Transfer function across a resistor phantom:

$$H(f) = {}^{V_{out}}/_{V_{in}}$$

Measurements in phosphate buffered solution:

$$V_1 = I[R_{PBS} + Z_{cuff}]H(f)$$

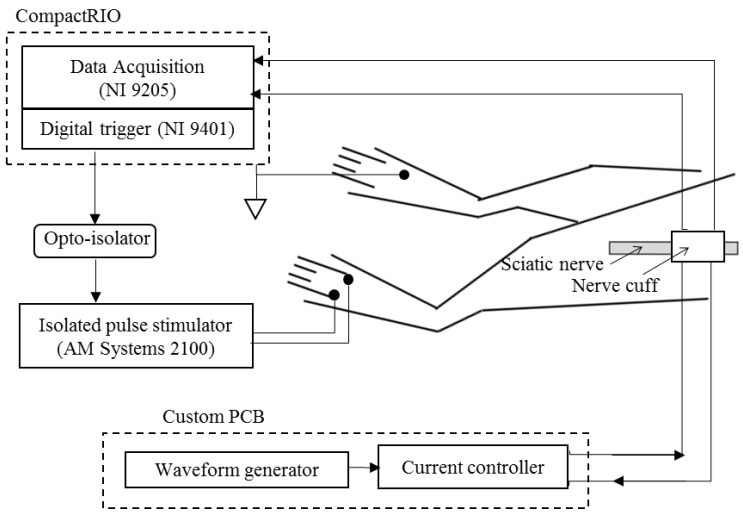
Measurements in cadavers:

$$V_2 = I[Z_{nerve} + Z_{cuff}]H(f)$$

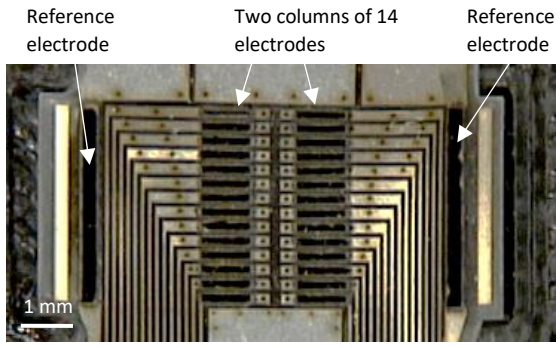
Nerve Impedance:

$$Z_{nerve} = \frac{V_2 - V_1}{H(f)I} + R_{PBS}$$

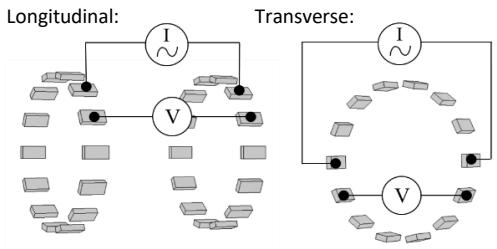
Hardware set-up:



Electrode array:



Nerve cuff configurations:



RESULTS AND DISCUSSION:

CAP frequency dominant at 400 – 500 Hz, with significant drop between 500 Hz and 1 kHz, and negligible power above 3 kHz. Results are specific to paw stimulation and sciatic recording in cadaver of Sprague-Dawley rat.

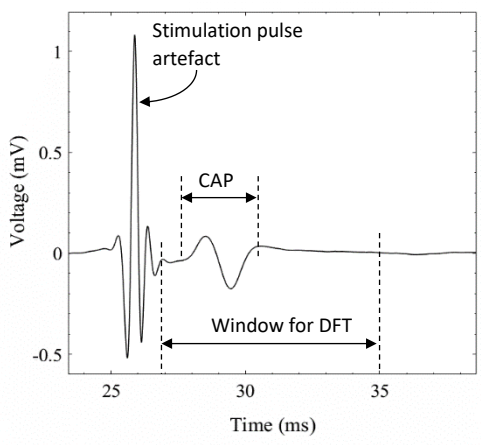
Transverse impedance showed local maxima at 4 and 8 kHz, and decline between 8 and 32 kHz. In agreement with data in [1]. Moderate agreement with modelling in [2], although more data at higher frequencies needed.

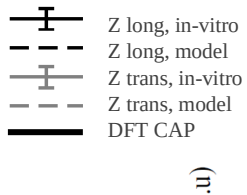
Longitudinal impedance showed decline between 1 and 32 kHz, with 80% reduction at 20 kHz. In broad agreement with modelling in [2].

National Instruments platform performance:

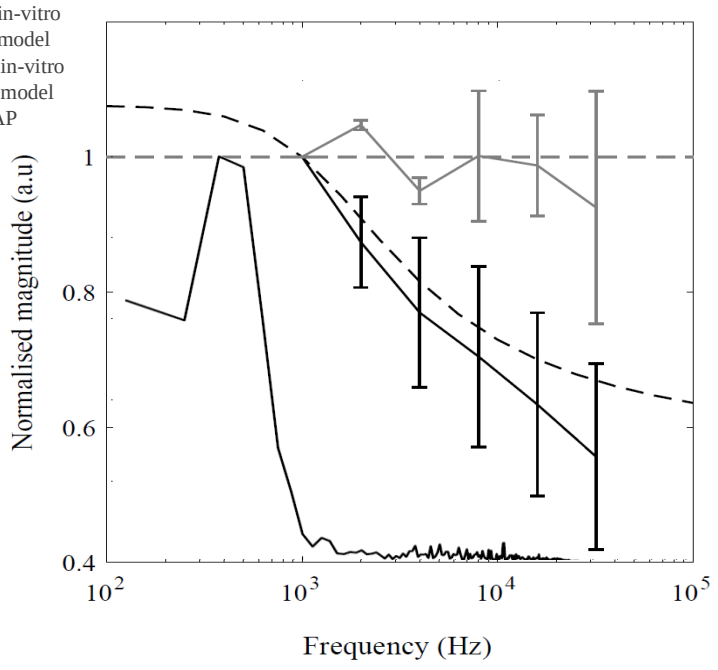
- 34 µV (6 σ) noise floor in CAP recording
- 167kS/s sufficient for 2 – 32 kHz signal

CAP:





Operating frequency analysis:



1. Y Aristovich, K., Donega, M., Blochet, C., Avery, J., Hannan, S., Chew, D., S Holder, D. Imaging fast neural traffic at fascicular level with electrical impedance tomography: proof of principle in rat sciatic nerve. *Journal of Neural Engineering,* 2018.
2. Hope, J., Vanholsbeeck, F., McDaid, A., A model of electrical impedance tomography implemented in nerve-cuff for neural-prosthetics control. *Physiological Measurement*, 2018.

CONCLUSIONS:

- Upper frequency limit, 80% reduction in magnitude: 20 kHz with Longitudinal current; potentially higher with Transverse
- Lower frequency limit, to avoid CAP artefact: 2 kHz