Measurement of electroporation pulses with oscilloscope, and voltage and current probes H1

Matej Reberšek
University of Ljubljana, Faculty of Electrical Engineering

Duration of the experiment: 60 min
Max. number of participants: 12
Location: Laboratory of Biocybernetics
Level: Basic

PREREQUISITES

No specific knowledge is required for this laboratory exercise.

THEORETICAL BACKGROUND

Electroporation is initiated by the delivery of electrical pulses to biological cells. Electrical pulses may vary in pulse parameters such as pulse shape, amplitude, duration and polarity. We may deliver different number of pulses, use combination of different pulses or vary pulse repetition rates. We also may deliver pulses in bursts or in different directions relative to the cell. The process of the electroporation is strongly dependent on the pulse parameters of the delivered electrical pulses. In order to control the process of the electroporation and to exactly specify the experimental method, and thus enable the reproduction of experiments under the same conditions, we should exactly determine and describe these electrical parameters. When reporting electroporation methods we should: 1) describe exactly how the electric pulses were measured; 2) provide time-domain waveforms of the electric pulse at the electrodes; and 3) calculate or otherwise determine to what electric field the cells were exposed to.

The aim of this laboratory practice is to learn how to use standard measurement equipment to measure or monitor the delivery of electroporation pulses. During the laboratory practice we will also learn what are the electrical parameters of electroporation pulses, what should we report in our studies concerning the measurement and what are some possible complications during the pulse delivery or measurement.

EXPERIMENT

Oscilloscope, and voltage and current probes will be used to monitor the delivery of the electroporation pulses to the load. We will first learn how to set the three main controls (vertical, horizontal and trigger) for adequate data acquisition. We will learn how to use measuring tool to automatically measure the pulse parameters, how to use sequencing to measure several pulses with low pulse repetition rate and how to set acquire to measure bursts of pulses.

We will monitor the delivery of microsecond and nanosecond pulses to the load. Learn how to detect disconnection and improper impedance matching of the load, and how a point of measuring and improper wiring may affect the measuring and the delivery of the pulse.

Several different commercial and prototype electroporators will be available during the exercise.

FURTHER READING:

Batista Napotnik T, Reberšek M, Vernier PT, Mali B, Miklavčič D. Effects of high voltage nanosecond electric pulses on eukaryotic cells (in vitro): A systematic review. *Bioelectrochemistry*, 110: 1-12, 2016.
Reberšek M, Miklavčič D, Bertacchini C, Sack M. Cell membrane electroporation –Part 3: The equipment. *IEEE Electr. Insul. M.,* 30(3): 8-18, 2014.
Silve A, Vézinet R, Mir LM. Nanosecond-Duration Electric Pulse Delivery *In Vitro* and *In Vivo*: Experimental Considerations. IEEE Trans. Instrum. Meas., 61(7): 1945-1954, 2012.

Kenaan M, El Amari S, Silve A, Merla C, Mir LM, Couderc V, Arnaud-Cormos D, Leveque P. Characterization of a 50-Ω Exposure Setup for High-Voltage Nanosecond Pulsed Electric Field Bioexperiments. *IEEE T. Biomed. Eng.* 58(1): 207-214, 2011.
Reberšek M, Miklavčič D. Concepts of Electroporation Pulse Generation and Overview of Electric Pulse Generators for Cell and Tissue Electroporation. In *Advanced Electroporation Techniques in Biology and Medicine*, *CRC Press*, 17:341-352, 2010.
Silve A, Villemejane J, Joubert V, Ivorra A, Mir LM. Nanosecond Pulsed Electric Field Delivery to Biological Samples: Difficulties and Potential Solutions. In *Advanced Electroporation Techniques in Biology and Medicine*, Pakhomov AG, Miklavcic D, Markov MS, *CRC Press*, 18: 353–368, 2010.

NOTES & RESULTS

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