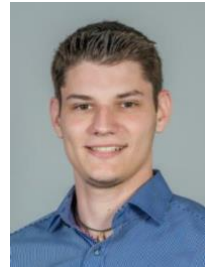


Development of a Multi-Modal Esophageal Pacing Catheter for Temporal Interference Stimulation

Daniel Walter Bürgler



Supervisors: Prof. Dr. Thomas Niederhauser, Msc Elisa Kaufmann
Institution: Institute for Human Centered Engineering, Bern University of Applied Sciences
Examiners: Prof. Dr. Thomas Niederhauser, PD Dr. med. Dr. phil. Andreas Häberlin

Introduction

Unconscious patients usually have to be ventilated mechanically. A major problem for patients needing a prolonged mechanical ventilation is loss of diaphragm muscle strength. A solution would be to replace the mechanical ventilation with the activation of the diaphragm by stimulating the left and right phrenic nerve. The stimulation technique of the phrenic nerves proposed in this work is through a novel deep brain stimulation (DBS) method called Temporal Interference stimulation (TIS). [1]

Materials and Methods

The shape for a 4-layer flexible printed circuit boards (FPCB) were designed using NX Siemens 12. Afterwards surface mount components and electrical routings were added with Altium Designer. The catheter uses passive electrodes to stimulate and measure the electrocardiogram (EMG). The pressure catheter uses miniature surface mount components and custom designed force sensing resistors to measure pressure in the esophagus and abdomen. Furthermore a TIS in vitro measurement setup should verify interference results from stimulating catheters.

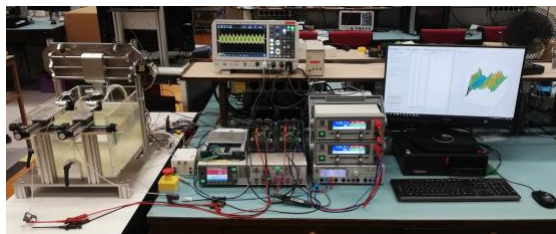


Fig. 1 TIS in vitro setup: It is capable of stimulating, switching electrodes and making measurements along a predefined route. The aim is to measure and display created TIS interferences.

Results

Three different FPCB catheter designs were developed. The stimulation catheter uses six electrodes with equal distance between them to stimulate circumferentially at 60°. The EMG catheter has electrodes distributed circumferentially at 90° and can detect the center of the diaphragm with a cross-correlation technique. A further catheter measures gastric and esophageal pressure. Furthermore a TIS in vitro setup was developed, which is able to make measurements with millimeter

precision. Interferences and expected voltage peaks in the center of directed electrodes pairs were able to be measured successfully.

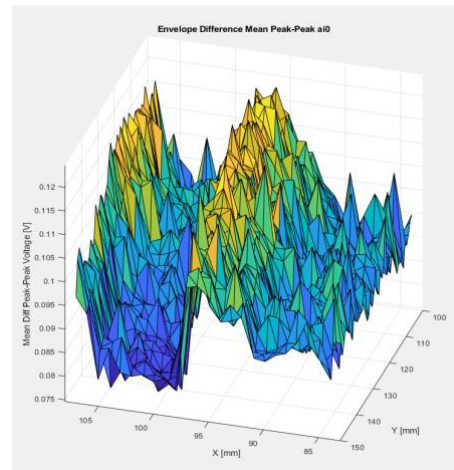


Fig. 2 Bipolar stimulation using two catheters with directed electrodes facing each other. The mean peak-peak voltage of the envelope at each point is displayed.

Discussion

Measuring TIS with two stimulating catheters in an in vitro setup worked and interferences could be displayed and analyzed. Using TIS with only one catheter will be a challenge. Most probably an external coil will have to be used as the second electrode pair. Moreover the goal would be to combine the three developed FPCBs onto one catheter.

References

[1] N. Grossman *et al.*, "Noninvasive Deep Brain Stimulation via Temporally Interfering Electric Fields," *Cell*, vol. 169, no. 6, pp. 1029-1041.e16, Jun. 2017, doi: 10.1016/j.cell.2017.05.024.