Intra-Ocular Pressure (IOP) measurements based on Goldmann applanation procedure as well as processing and analyzing software tools

Detailed Summary

We are collaborating towards developing a new system to measure Intra-Ocular Pressure (IOP) and biomechanical characteristics of the cornea for long periods of time (24 hours typically). This system is dedicated to world ophthalmologist community and aims to drastically change glaucoma screening techniques and treatments.

Compared to existing concurrent products, IOP-24 is distinguished precisely by the fact that it applies the principle of applanation known and accepted for 50 years by most ophthalmologists. It meets the expectation of ophthalmologists who want to measure IOP during 24 hours in order to determine the IOP peak and to establish the adapted treatment and the dosage thereafter. About 1 to 3% of the global population suffers from glaucoma and needs treatment. Presently, Glaucoma is detected by spot measurement of IOP with a Goldmann tonometer. In one-third of the cases this spot examination is insufficient and needs to be complemented by prolonged measurement over a period of 24 hours. The IOP-24 solution being developed by TISSOT Medical Research (TMR) in collaboration with ESPLAB, could serve as an apt alternative for such cases.

Furthermore, because the system is designed to also measure the biomechanical characteristics of the cornea, it aims to provide the Goldman-correlated IOP (IOPg) as well as the Corneal-Compensated IOP (IOPcc), which is a more accurate measurement of the IOP. Currently, no portable device in the world is able to provide IOPcc for 24 hours.

The proposed system is composed of 2 parts - the sensor embedded in a contact lens (figure 1) and a wireless reader able to post process recorded measurements (figure 2). The reader communicates with the sensor through an inductive coupling and performs measurements periodically. In the first phase of the project, ESPLAB has developed and validated the electronics and the signal processing parts of the system. In the second phase, the aim is miniaturizing electronics as well as reducing power consumption by developing an Application Specific IC (ASIC). In parallel, TMR and its partners are developing and validating the sensor lens (through clinical trials).

The measurement of IOP relies on the eyelid pressing on the sensor. This creates variations in the capacitance of the sensor (based on the IOP and the biomechanical properties of the cornea), which, in turn, modifies the resonant properties of the sensor’s electrical tank. In order to obtain measurements as frequently as the movement of the eyelid, the data has to be sampled sufficiently fast in order to extract biomechanical properties of the cornea. The idea is, therefore, to perform fast frequency sweeps on the resonant circuit of the sensor and read out the associated response and extract IOP characteristics by post-processing the recorded data. From empirical and theoretical considerations, the data from the sensor should be read in 0.2 ms (acquisition duration) and such readings should be made every 1 ms (sampling interval) for the whole length of the blink of an eyelid that lasts for about 300 ms on an average.

During each reading in the acquisition duration, multiple frequency sweeps are made to identify the resonant frequency of the sensor circuit. All measurements have to be repeatedly done for a duration of 24 hours to get the data required for extracting IOPg and/or IOPcc. It is thus mandatory to develop a high-speed measurement system. Moreover, the frequencies involved in the process requires that this measurement take place near the lens mandating low space requirements. In addition, in order to ensure portability and low-power requirements, a low power ASIC is perfectly suited for all the requirements.

The ASIC, therefore, has to be capable of generating a range of frequencies to be able to feed the resonant sensor circuitry with input sinusoids with varying frequencies. Subsequently, it should have a readout circuitry to read out important electrical characteristics from the sensor circuitry and then be able to send them for post-processing so that the biomechanical properties can be assessed. ESPLAB is responsible for developing the ASIC and the associated software for generating useful results on a screen in a format readable by medical professionals. The other aspects of the system will be covered by TMR and its partners.