Frequency and Electrode Separation Recommendations for EDA Measurements

S. Sridhar[1], T. J. Akl[1]

[1]Analog Devices Inc., Wilmington, MA, USA

Abstract

Electrodermal Activity (EDA) is a measure of changes in the conductivity of the skin. It has have been found to be indicative of the individual's autonomic nervous activity which is correlated to their stress and emotional state. These conductivity changes are tracked by injecting a small electric current directly into the skin and measuring the induced voltage drop over time. With increase in recent interest in wearable technology and its use in tracking vitals such as stress through EDA, there has been a growing need to optimize the design of dry-electrodes that are used in EDA measurements.

In this work, we have used a Frequency domain study using the AC/DC Module Electric Currents Physics Interface on COMSOL Multiphysics to develop a model of the forearm as layers of tissue dielectrics. Tissue layers include the skin, fat, bone and muscle in proportions found in the human forearm. The dielectric properties of these tissues were fed into the model. Since typically, we are interested in changes in relative skin conductivity changes over time, a 2-electrode method of sensing is employed and simulated in COMSOL though the use of 1 cm2 square electrodes.

To simulate sweating that is picked up by EDA, the conductivity of the skin was changed between two levels simulating dry and hydrated skin. As a part of the post-processing, the integral of all the currents magnitudes at a mid-slice between the two electrodes are calculated for each skin hydration/conductivity state. The normalized change in current, k, caused by the increase in skin hydration is calculated to determine the sensitivity to sweating changes. We computed k for different frequencies between 100 Hz and 200 kHz and electrode separations ranging between 0.5 cm and 5 cm. For a fixed increase in skin conductivity and fixed voltage drop across the electrodes, a higher value of k indicates a better pick-up of skin conductivity changes.

It has been found through the simulations that k values are highest at low frequencies (=100 Hz) and low electrode separations (=0.5 cm). The extent of impact on sensitivity at different frequencies and separations have also been studied and experimentally validated. We conclude that choosing low frequencies and low electrode separations optimizes for EDA pick-up. This is a potentially useful design consideration when optimizing for pick-up of skin conductivity changes in EDA measurements.