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Application Note 284: fNIR Systems – Dark Current Measurements

fNIR Systems provide a unique feature that can be useful for identifying certain types of noise within recordings. In addition to extracting measurements from an LED light source at wavelengths of 730 and 850 nm, this feature enables the fNIRS imager to record measurements under “dark current” conditions. While raw intensity data taken at 730 and 850 nm wavelengths can be used for hemoglobin content extraction, the “dark current” measurements can be utilized for noise detection. Note that dark current measurements are always recorded in fNIRS data output files (.nir and .oxy) and can be monitored during sensor placement, baseline, and overall testing measurement periods by selecting **** under **** buttons in COBI studio.

When the sensor is making proper contact with the skin (free of ambient or reflected light leakage), the dark current condition (green trace) measurement should remain flat at certain, very low voltage levels throughout the data collection period (see Figure 1 below). However, if the sensor loses contact (or was improperly attached to the forehead), ambient light leakage can be an issue. Leakage can result when the LED light source at 730 and 850 (blue and red traces respectively) becomes illuminated for short or extended periods as shown in Figures 2, 3, and 4. All data sets in Figures 1 through 4 were collected from subjects wearing the fNIRS imager while performing walking and talking tasks. In all cases, light leakage noise resulting from improper sensor/skin contact can be identified by checking the dark current measurements.

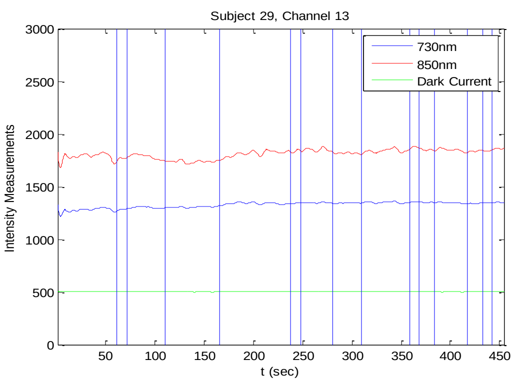

Figure 1

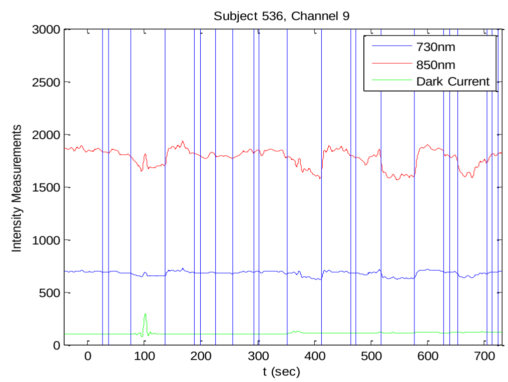

Figure 2

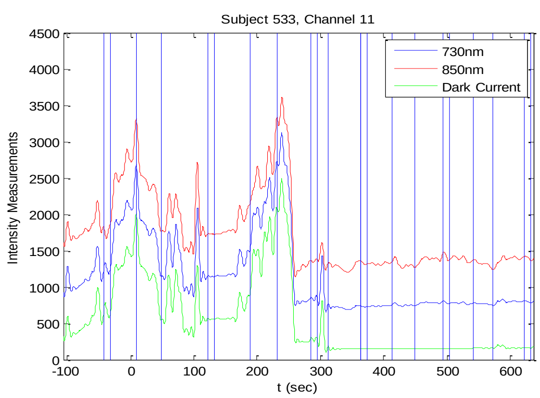

Figure 3

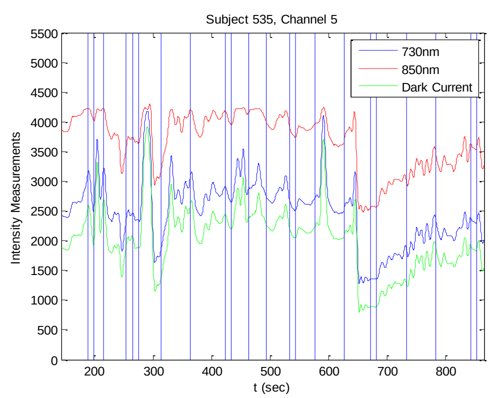

Figure 4

Time periods during which dark current measurements do not remain flat in close correlation with measurements taken at 730 and 850 nm can help identify noisy data segments. These regions can subsequently be marked and discarded from further hemoglobin content extraction analysis. Since intensity measurements of 730 and 850 nm wavelengths in these regions are not the result of light reflected back from the brain (and masked mostly by the light leaked from other sources), it wouldn’t be warranted to remove such noise from 730 and 850 nm measurements using techniques such as optimal filtering or blind source separation.

In addition to light leakage, other types of noise can be identified and marked using dark current measurements. These include electrical noise resulting from cable movement, or from other external devices used in the same environment during fNIRS testing. In the example shown in Figure 5 below, data was collected from a subject during surgery under general anesthesia. The extreme noise segments correspond to regions where surgical electric cuttery was used to open and close the surgical area on the subject. Even though such high amplitude (low SNR) and high frequency noise is very apparent, such regions can still be verified by using dark current measurements, and can subsequently be discarded from further analysis.

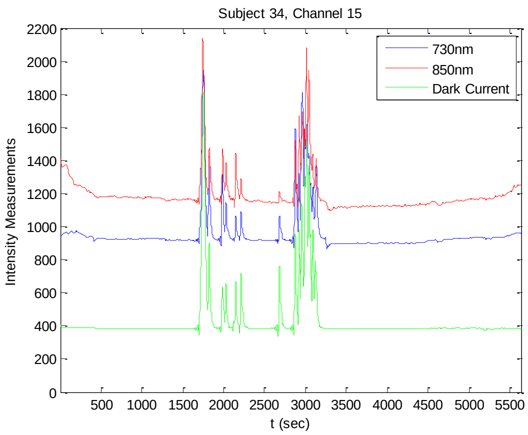

Figure 5

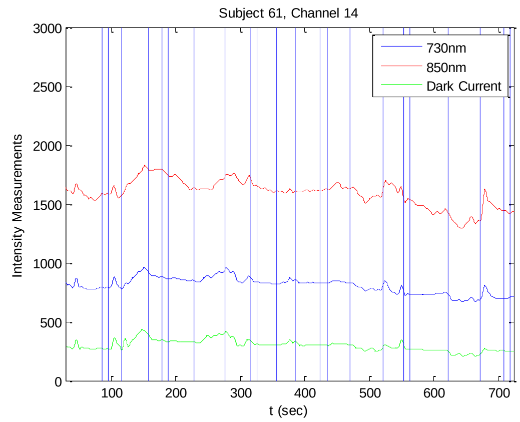

Figure 6

It can be argued that noise signatures in the above examples are readily visible and identifiable to the naked eye. Even in such obvious cases, it's prudent to employ a justifiable secondary measure for verifying the presence of this type of noise.

In addition, there can be cases where noise interference is less visible, as shown in Figure 6 above right. The intensity measurements at 730 and 850 nm wavelengths look viable and noise-free at first glance. However, when the dark current measurement is examined, a high correlation between all visible measurements is observed, suggesting the presence of light leakage. Hence, these measurements may not be reliable. Therefore, the dark current measurement feature can be a useful barometer for identifying this type of noise, offering a means for eliminating uninformative data from further analysis.