Spreeta™
Noise and Baseline Drift Minimization

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Noise and Baseline Drift Minimization

ABSTRACT

This process describes how to minimize noise and baseline drift while performing an experiment with a Texas Instruments (TI™) Spreeta™ sensor, which is included in the *Spreeta Evaluation Kit* (formerly known as the *TISPR–1 Experimenter's Kit*[†]).

Introduction

There are several sources of baseline noise and drift in a typical experiment using the Spreeta sensor. Many of these sources arise from experimental technique and can be eliminated. Ultimately, the reduction of noise levels is limited by the sensor design. Typically, the lowest noise levels achieved for the 8-bit analog-to-digital (A/D) system used in today's Spreeta evaluation kit are on the order of 3.0 $\times$ E–6 refractive index units (RIU).

> **NOTE:** The use of a 12-bit A/D system further reduces the observable noise level to 1.5 $\times$ E–6.

Optimum baselines are obtained by following some simple procedures.

Sensor Preparation

Air Initialization

The air initialization procedure prepares the Spreeta sensor for refractive index measurements by:

1. Setting the LED intensity and detector array integration times to maximize the sensor signal without saturating the output at any pixel.
2. Looking at the detector background with the LED off.
3. Correcting for pixel-to-pixel response non-uniformity.

The last plot shown during the air initialization procedure is a plot of relative light intensity vs pixel number. Following a good air initialization procedure, all 256 pixels should have values of 1.00 +/– 0.01, as shown in Figure 1.

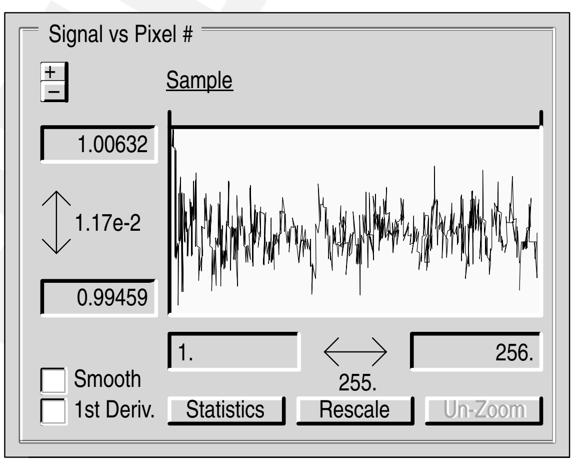

Figure 1. Spreeta Air Initialization

† This test kit is being sold by Texas Instruments (TI) for experimental purposes only and not for commercial use.

NOTE: It is extremely important that a good air initialization is obtained before attempting to take liquid measurements.

The air initialization must be done with an absolutely dry sensor surface and without any background (room) light.

Monitoring a Liquid Versus Time

After a stable air initialization is obtained, the sensor is ready to take data in a liquid. The active sensing surface should be immersed in the liquid solution being analyzed. The flow cell kit is recommended for this purpose and it is required when using disposable slides. To instruct the program to take a set of sample data, click on the SAMPLE command button. A plot of signal magnitude versus pixel position is generated, as shown in Figure 2. This plot is referred to as the surface plasmon resonance curve (SPR) curve.

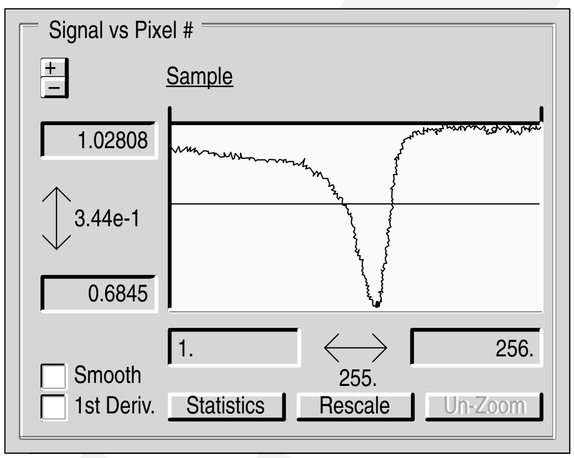

Figure 2. Spreeta SPR Curve

A minimum point will be seen in the SPR curve. The pixel position at which the minimum point occurs depends on the refractive index of the liquid next to the gold sensing surface. The depth of the SPR curve can range between 25% to 80%. This variation does not affect the sensor performance.

Taking a sample curve with the MONITORING menu item allows you to set several important parameters before you acquire data with the monitoring menu item. The SPR curve should have a fairly smooth appearance. There may however, be times when a glitch appears in the SPR curve, as shown in Figure 3. This is usually due to surface fouling in the active sensing region. It is still possible to use the SPR curve as long as the glitch is not near the minimum point. You may selectively exclude regions of data from analysis by using the mouse (left button) to *pull* the green tables on the left and right hand sides of the plot. In Figure, 3, the hatched region has been excluded from the analysis.

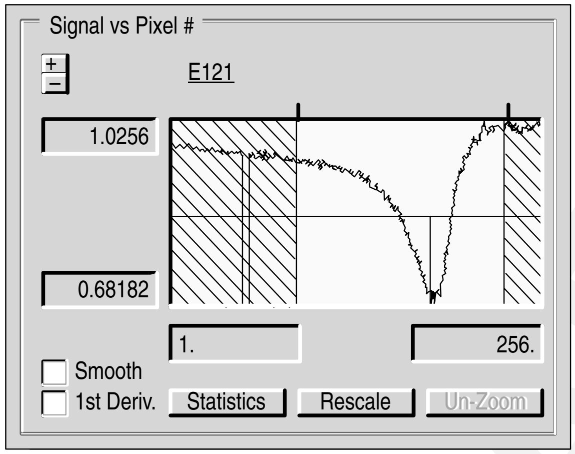

Figure 3. Excluding Regions of the SPR Curve From Analysis

Prior to performing any analysis, the SPR curve can be smoothed. This leads to reduced noise when tracking refractive index versus time. The smoothing algorithm is found under the OPTIONS/ANALYSIS menu item. It is a least-squares smooth that incorporates anywhere from 0 to 12 points to either side of a data point when determining the smoothed value of that point.

Several SPR curve analysis methods are available under the OPTIONS/ANALYSIS menu. TI routinely use the First Moment Analysis Method to calculate the first moment of the SPR curve below some baseline. This baseline is generally chosen to be approximately 50% of the resonance depth as is indicated by the horizontal line in Figure 3.

For a more complete explanation of the various analysis methods, please see our web site at www.ti.com/spreeta, or the *Spreeta Evaluation Kit User's Guide*.

Gold Spreeta Surface Cleaning

Baseline drift is often observed when the gold sensing surface has not been properly cleaned before an experiment. Surface contaminates can slowly dissociate from the sensing surface when buffer solutions are flowed across it. TI Application Brief 002, *Gold Spreeta™ Sensor Surface Cleaning*, describes several methods for thoroughly cleaning a gold Spreeta surface.

Buffer Preparation

TI recommends using deionized or purified water to prepare buffers. Filtering all liquids, buffers, and samples helps prevent suspended matter from randomly attaching to the Spreeta surface and interfering with the intended signal. Bubbles should be avoided. For critical applications, liquids should be degassed. TI recommends using a disposable vacuum filter unit and a house vacuum to both filter and degas solutions.

Vacuum Pumping for Pulse-Free Flow

Uniform pulse-free flow is essential to reduce baseline noise. Flow and noise are coupled because the Spreeta sensor is typically not at the same temperature as the liquids used in an experiment. When liquid flows into the sensor, it experiences a small temperature change and a corresponding refractive index (RI) change. When flow is constant, a steady-state temperature is established in the flow cell. A pulsed flow results in a slight change of temperature and RI for the liquid resident in the flow cell, as shown in Figure 4. TI Application Brief 005, *Vacuum Pumping for Pulse-Free Flow*, describes a simple low-cost vacuum pumping method to produce pulse-free flow in the Spreeta sensor.

Refractive index changes may be observed with any pumping method when the flow rate is stopped to change the feed liquids. When you switch between two buffer solutions, TI recommends using a voltage-regulated 3-way solenoid valve. The Lee Company LFAA Series of 3-way solenoid valves is an example.

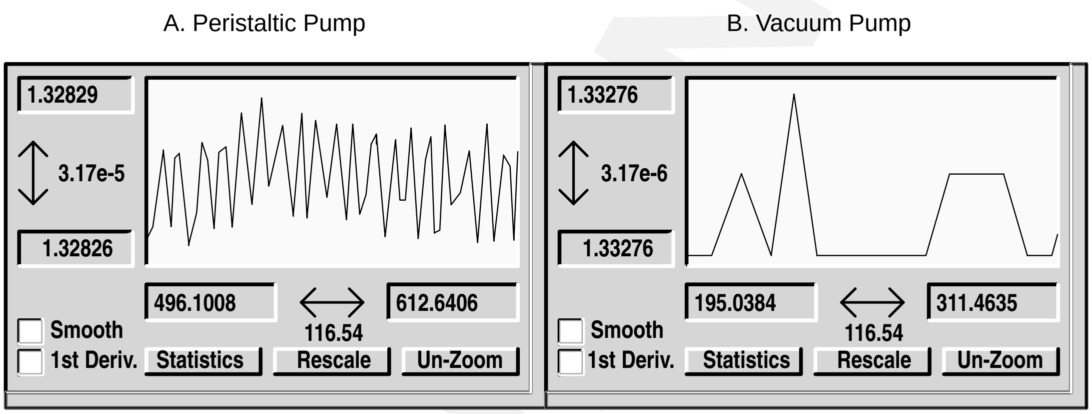

Figure 4. Baseline Noise Induced by Pulsed Flow

Phosphate buffered saline (PBS) is pumped at a flow rate of 0.5 ml/min using either a peristaltic pump (Figure 4–A) or a vacuum pump (Figure 4–B). Each pulse of the peristaltic pump results in a slight change in the temperature, and hence, the RI of the liquid resident in the flow cell. In both cases, data is acquired with a DSP version of the Spreeta sensor.

Temperature Fluctuations

Since RI is sensitive to temperature, a controlled environment is important for good Spreeta measurements. The Spreeta sensor has no active temperature control, and analyses are usually performed at room temperature. The sensor should not be operated in drafty areas, or areas adjacent to air conditioning and heating vents. The sensor can be insulated from some environmental changes by operating it inside the black box that comes with the *Spreeta Evaluation Kit* (formerly known as the *TISPR-1 Experimenter's Kit*). It is also important to bring all buffers and samples to room temperature before running a Spreeta experiment.

Summary

The Spreeta sensor is capable of achieving noise levels on the order of $3.0 \times E{-6}$ RIU when some simple experimental procedures are followed. These procedures include the proper cleaning of the gold sensing surface before use and the proper preparation of buffers and samples. Temperature variations should be monitored and controlled as much as is feasibly possible. For optimal performance of the Spreeta sensor device, TI recommends pulse-free flow of liquid. More information on Spreeta is available at www.ti.com/spreeta. Send all questions and comments to spreeta@ti.com.

References

1. *Spreeta Evaluation Kit User's Guide*, Texas Instruments Incorporated, Dallas, September 1999.