Spreeta™
Vacuum Pumping for Pulse-Free Flow

Application Brief

Number 005

1999 Microcomponents Technology

SLYA019A

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.

Vacuum Pumping for Pulse-Free Flow

ABSTRACT

This process describes vacuum pumping, which enables pulse-free flow of liquid and reduces baseline noise in the Texas Instruments (TI™) Spreeta™ sensor device, which is included in the *Spreeta Evaluation Kit*, (formerly known as the *TISPR-1 Experimenter's Kit*†).

Introduction

Uniform pulse-free flow is essential to reduce baseline noise and drift. Flow and noise are coupled because the TI Spreeta sensor is typically not at the same temperature as the liquids used to determine a measurement. As a result, the steady-state temperature in the flow cell is dependent on the temperature difference and the flow rate. Even small changes in the steady-state temperature of the liquid in the flow cell result in refractive index changes or baseline noise. Pulse-free flow can be achieved by using a constant vacuum to pull liquid through the sensor.

Vacuum Pumping Apparatus

The vacuum pump apparatus consists of a source of constant vacuum (for example, a house vacuum, 24 to 28 inches of mercury), a liquid trap, and two valves. Figure 1 shows the configuration of the various elements.

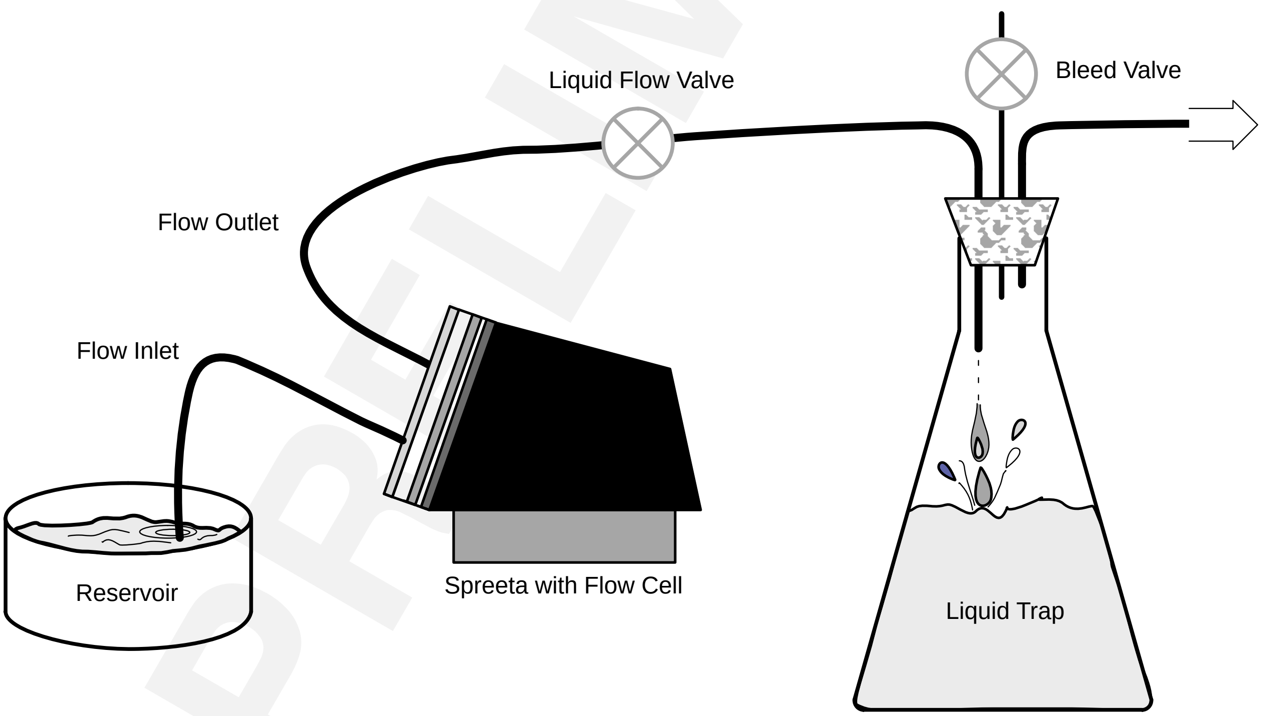


Figure 1. Vacuum Pump Configuration

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

Flow is established by pulling a vacuum on the outlet side of the sensor flow cell. The vacuum in the liquid trap is adjusted with the bleed valve, and the liquid flow rate is adjusted with the liquid flow valve. The flow rate can be measured easily by counting drops as they fall in the liquid trap.

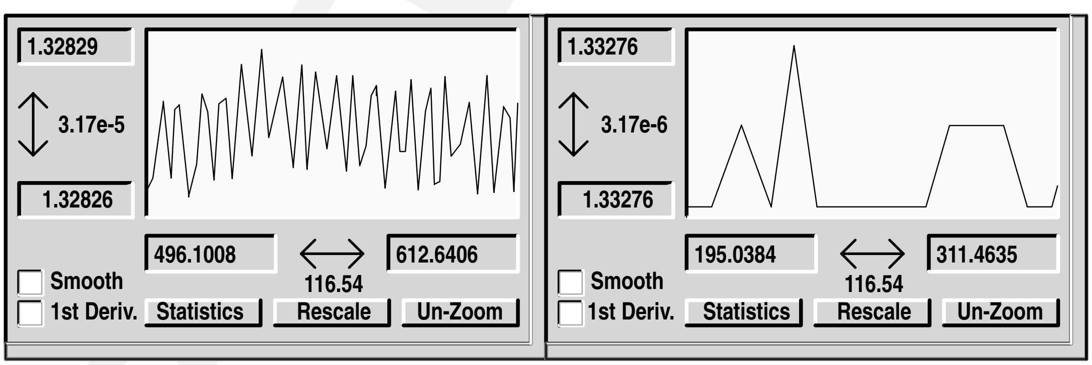
A 500-mm side arm Erlenmeyer flask fitted with a three-holed stopper is suitable for the trap. A transparent trap allows drop counting to measure the flow rate. The bleed valve is used to reduce the vacuum inside the trap. Too much vacuum will cause degassing of aqueous liquids and create bubbles in the fluid flow valve. You can improve the system by adding a regulator to accurately set the pressure difference between the atmosphere and the trap. When the bleed valve is set, the liquid flow valve is used to adjust the flow rate. Flow rates between 0.1 ml/min to 1 ml/min have been previously generated with this method. A two-way solenoid valve can also be inserted near the liquid flow valve to allow automated control of liquid flow. One benefit of this design is a very small dead volume up stream from the sensor, which allows for rapid switching between various liquids.

Liquid Flow and Baseline Noise

A comparison between a peristaltic pump and the vacuum pump illustrates the effect of pulsed flow on sensor performance (Figure 2). In some cases, baseline noise can be reduced by an order of magnitude by the elimination of pulsed flow. Typically, the sensor temperature is a few degrees higher than the room temperature or the liquid temperature. As liquid flows into the sensor, the temperature of the liquid increases and a corresponding refractive index decreases. If the sensor temperature is lower than that of the liquid, the effect is reversed. If the flow rate is not constant, this temperature effect will cause a change in the refractive index of any liquid used to establish a baseline.

> **NOTE:** A refractive index change may be observed with any pumping method when the flow rate is stopped to change feed liquids.

A. Peristaltic Pump B. Vacuum Pump



NOTE: Phosphate buffered saline (PBS) is pumped at a flow rate of 0.5 ml/min using a peristaltic pump (Figure 2–A) or a vacuum pump (Figure 2–B). Each pulse of the peristaltic pump results in a slight change in the temperature and the refractive index of the liquid resident in the flow cell. In both cases (Figure 2–A and Figure 2–B), data was acquired with a DSP version of the Spreeta sensor control electronics using a 12-bit analog-to-digital converter (ADC). This ADC lowers the attainable system noise level to approximately 1.5 x E–6 refractive index units.

Figure 2. Baseline Noise Induced by Pulsed Flow

Summary

Vacuum pumping provides a simple low-cost method of producing pulse-free flow for the Spreeta sensor device. Pulse-free flow is an important design feature to optimize the performance of the Spreeta sensor device. 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.