Measuring Medical Pump Accuracy with LabVIEW

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The Challenge: Measuring the very low flow rates of medical pumps accurately and analyzing and displaying the data efficiently.
The Solution: Building a LabVIEW-based automated test system.

Introduction

Medical pumps are an indispensable tool to medical personnel because of their convenience, low price, and ability to deliver fluids accurately and safely. These pumps are used in a wide range of clinical situations, such as surgical procedures, treatment of pain, and diagnostic procedures. Typically, medical pumps use a disposable syringe, a connector tube, and a catheter to deliver small quantities of fluids such as anesthetics, analgesics, and diagnostic agents over long periods of time.

To address this problem, we chose LabVIEW for developing a computerized test system that could simplify data collection, perform advanced data analysis, and graphically display data.

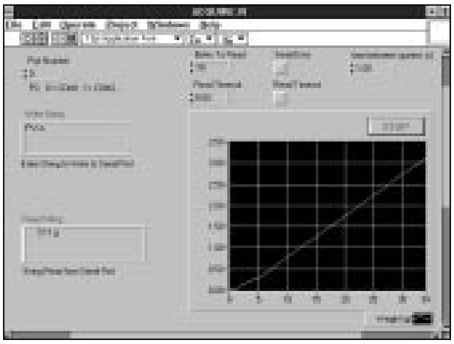
Because medical pumps are used to deliver potent drugs and to obtain diagnostic information, pump accuracy, as specified by the manufacturer, is critical. Until recently, pump manufacturers specified the pump accuracy as just a percentage, with no indication as to whether this was the drive, volume, or flow rate accuracy. As a way of eliminating this confusion, a test standard was proposed by the International Electrotechnical Commission (Draft IEC-601-2-24). In this standard, performance of the pump is characterized by (1) measuring flow rate over time from the start of the infusion (start-up curves), and (2) determining the percentage variation in flow rate during various time periods (trumpet curves). With this data, users can ensure correct dosage and optimum patient safety.

The Medical Test System Pump

Because most medical pumps operate at low flow rates (sometimes on the order of milliliters per hour), applying the test methods outlined in the standard is time consuming and computationally intensive. To address this problem, we chose LabVIEW for developing a computerized test system that could simplify data collection, perform advanced data analysis, and graphically display data.

The Test System

The test system is made up of several components – an electronic scale, a Pentium PC, LabVIEW software, and an interface cable. According to the test standard, fluid flow is defined as the weight of the fluid delivered, in grams, over a defined period of time. We placed a beaker on the scale and used it to collect the fluid delivered by the pump. To acquire data from the scale, we built a custom cable to connect the RS-232 serial port on the scale to the serial port on the PC. LabVIEW was ideally suited to operate the test system because of its flexibility and programming ease. The LabVIEW built-in serial port virtual instruments (VIs) provided a great starting point for performing bidirectional communication with the scale via RS-232. The LabVIEW acquisition VI periodically queries the scale for information, so you can start a test and leave it running with minimal operator intervention.



The LabVIEW Acquisition VI Front Panel

Once we collected data, we developed a separate LabVIEW VI to perform the start-up and trumpet curve analysis. In this analysis VI, the weight (grams) as measured with the scale was converted to flow rate (ml/minute) by dividing by the fluid density and test duration. We used a LabVIEW waveform graphic on the front panel to view the flow rate over time. This curve displays flow rate continuously from the start of the infusion, so users can visually observe flow rate uniformity and any delay in delivery due to mechanical compliance.

Unlike the continuous start-up curve, the trumpet curve displays data averaged over particular time periods or “observation windows.” Trumpet curves are named for their distinctive shape, converging to the right with time on the x-axis and flow rate accuracy on the y-axis. The trumpet curve defines, for a programmed flow rate, the maximum and minimum percentage variation from the expected flow rate relative to the observation window. Over short

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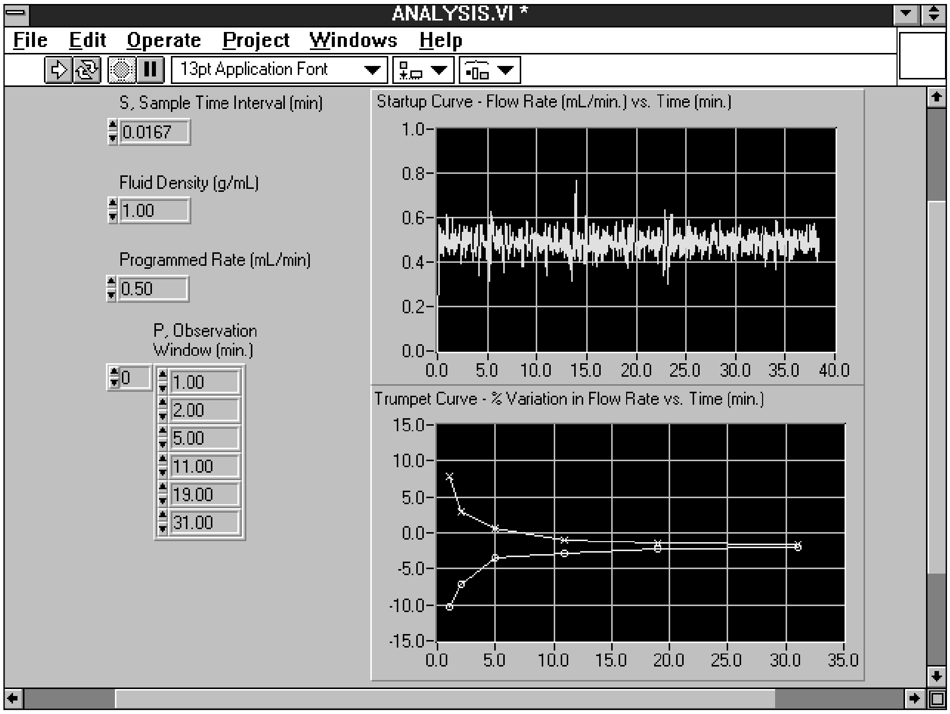
observation windows, fluctuations in flow rate have a greater effect on accuracy as represented by the bell of the trumpet. As the observation window increases, short-term fluctuations have little effect on accuracy as represented by the flatter part of the curve.

To implement the trumpet algorithm, we specified the observation windows and programmed flow rate on the LabVIEW front panel. Flow rate variations were determined as a percentage by subtracting the programmed flow rate from the measured flow rate, then dividing this difference by the programmed flow rate. Within each observation window, the maximum and minimum variations were determined, and graphed relative to the observation window. With this type of analysis, you can correlate the half-life of a drug to be administered with the observation window interval in the graph and decide if the pump is suitable for that application. The built-in LabVIEW array functions greatly simplified the start-up and trumpet analysis, making it easy to “wire” the data directly into to the array functions without any programming.



The LabVIEW analysis VI shows a sample start-up curve and a trumpet curve.

Conclusion

This LabVIEW-based test system has been an effective development and checkout tool for our R&D laboratory. This type of testing would have been a difficult task without LabVIEW, which simplified data collection and analysis, decreased testing time, and reduced the amount of operator interruption. LabVIEW also eliminated the need for separate data acquisition, spreadsheet, and mathematical software packages. With its numerous features, LabVIEW made implementing this new test and measurement method easy.

This test system was originally intended for internal R&D use. However because it has been such a valuable tool, several other departments are currently evaluating it. The demands on the test system are constantly changing, but with LabVIEW, we can easily modify the system.

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