Response Time of the Model 280 NOA™ Nitric Oxide Analyzer

Accurate measurement of rapidly changing nitric oxide concentrations such as exhaled breath or monitoring nitric oxide in a ventilator circuit requires a nitric oxide analyzer with a fast response time.

There are two factors that effect the measurement time for gas phase nitric oxide (NO); response time of the analyzer and the lag time due to the dead volume in the sample inlet line. The response time of the analyzer is determined by the speed of the electronics and signal processing system. The lag time is determined by the flow rate of gas into the analyzer, the volume of the internal plumbing and the length and inside diameter of the tubing from the analyzer to the sampling point.

To measure the response and lag time of the Model 280 Nitric Oxide Analyzer (NOA), a series of experiments were performed. The response time of the electronics was measured using a light emitting diode and a function generator to turn the LED on and off. The lag time was measured using a solenoid valve and function generator. The common leg of the valve was connected to the inlet of the analyzer and the other legs connected to two gas streams containing different levels of NO (< 5 ppb and 100 ppb). As the solenoid valve was activated, the vacuum pump of the NOA alternately samples either the <5 ppb NO stream or the 100 ppb NO stream. The solenoid valve was connected either directly to the inlet of the frit restrictor of the NOA using a minimum length of tubing or to different lengths of 1/8" OD Teflon® tubing. All tests were performed using the standard frit restrictor that draws gas into the analyzer at 160 standard cubic centimeters per minute (flow rate at 760 torr and 0°C).

For the LED and solenoid valve experiments, the output of the NOA and the switching signal from the function generator were connected to an Analog to Digital Converter (ADC) and the digital data used to calculate response times.

Response Time of the Model 280 NOA Electronics

The Model 280 NOA has two analog and one digital output. For these experiments, the trigger signal from the function generator could not be precisely matched to the digital output and, therefore, only the response time of the analog outputs were measured. The two analog outputs from the NOA are the signal taken directly from the amplifier of the photomultiplier tube (PMT) and the scaled output of the NOA. For the scaled output, signal from the amplifier of the PMT is electronically filtered, converted to a digital signal using an ADC, converted by microprocessor to match the user selected units and output range, then converted back to an analog signal by a Digital to Analog Converter (DAC).

The results from the led test showed the response time for the pmt amplifier signal to be 200 milliseconds to reach 90% of the full-scale signal. The response time of the scaled analog output is 600 milliseconds. The scaled output is slower due to the additional electronic filtering and the time required for the analog to digital and digital to analog conversions. These response times represent the fastest possible response of the NOA. In practice, slower response will be observed due to the lag time.

Lag time of the Model 280 NOA

Figure 1 shows a plot of the trigger signal of the function generator (dashed line) and the NOA signal from the PMT amplifier output when the solenoid valve is connected directly to the inlet of the NOA flow restrictor. When the solenoid valve is activated, the analyzer switches from sampling a low level NO gas stream (< 5 ppb) to a stream containing -100 ppb NO. When the solenoid valve is connected directly to the NOA inlet, the time for the PMT amplifier output to reach 90% of the full scale signal was

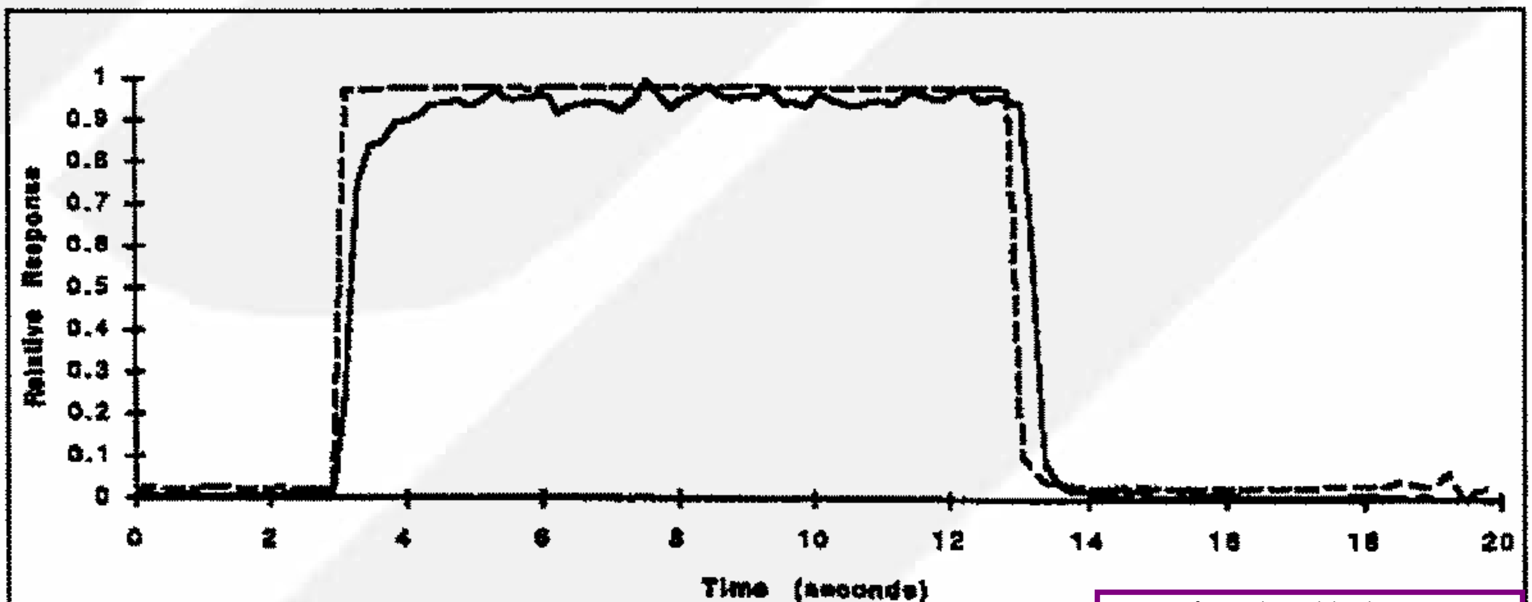

Figure 1: Response of NOA (solid) and trigger (dash)

0.73 seconds. This time is the result of the response time of the electronics (200 msec) coupled with the lag time of the internal tubing from the frit restrictor to the reaction cell (530 msec).

For most applications, some length of tubing will be required to connect the NOA inlet to the sampling point. Figure 2 and 3 show the solenoid valve trigger signal (dashed line) and PMT amplifier output (solid line) when 6 foot and 12 foot lengths of 1/8" OD Teflon® tubing are installed between the NOA inlet and the solenoid valve. For a 6 foot length of Teflon® tubing, the NO peak is observed approximately I second after the solenoid valve is actuated. With 12 feet of tubing between the analyzer and the valve, the NO peak is observed about 3 seconds after the valve is actuated.

The results from these experiments show that response time of the PMT amplifier output of the NOA is fast enough for accurate measurement of changing NO concentrations. As noted above, the response time of the scaled analog output is slower and the PMT amplifier analog signal should be used for rapid response. The lag time can be minimized by using shorter and/or smaller OD Teflon® tubing for sample collection.

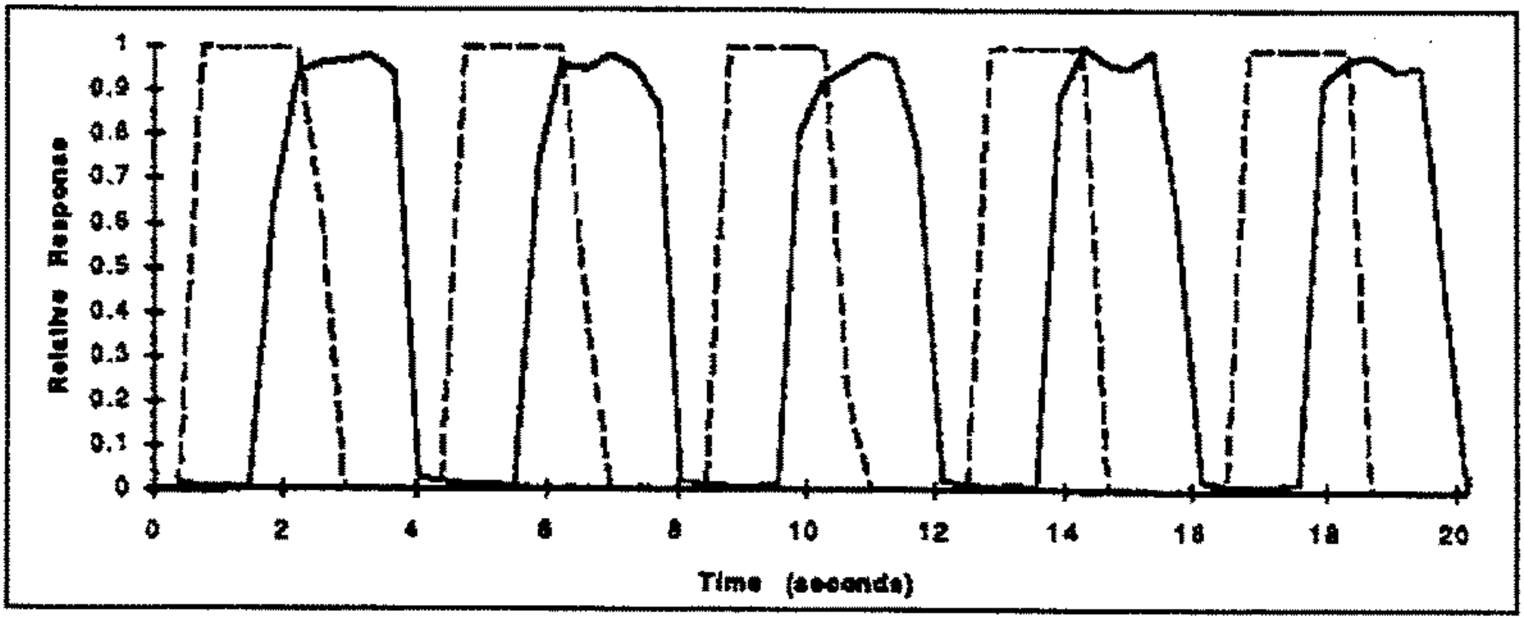

Figure 2: Response of NOA (solid) and trigger (dash) for <5 ppb and 100 ppb NO using a 6 foot, 1/8” OD Teflon® sampling line.

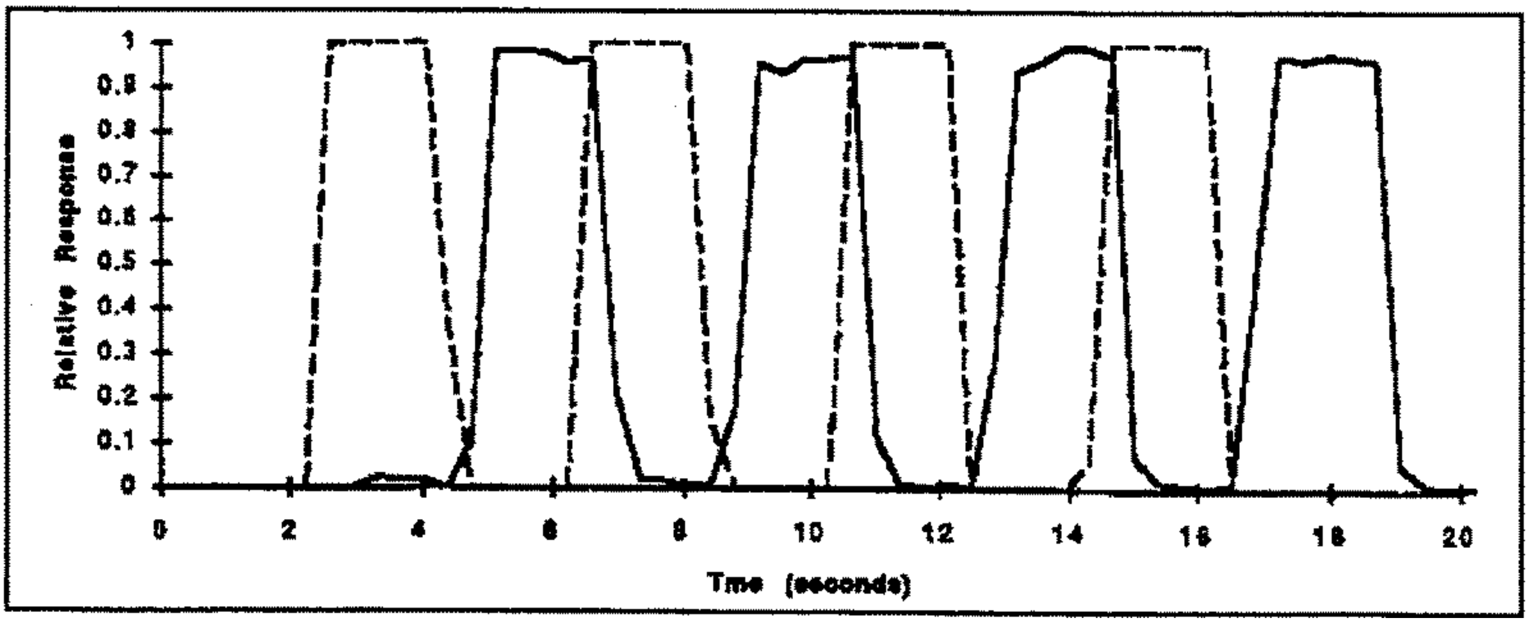

Figure 3: Response of NOA (solid) and trigger (dash) for <5 ppb and 100 ppb NO using a 12 foot, 1/8” OD Teflon® sampling line.