Silanna UV

REFERENCE DESIGN

Nitrate Sensor Reference Design

1. Introduction

Nitrate contamination over 10mg/L-N in drinking water can have harmful effects on humans according to the United States Environment Protection Agency[i] and Minnesota Department of Health, USA[ii]. With the increased regulation, the need for monitoring and controlling dissolved nitrate has taken an important priority in the domain of water quality monitoring. The property of nitrate to absorb the far UVC band of light with a wavelength under 240nm allows a quick and effective way to measure low levels of dissolved nitrate.

2. Overview

Traditionally, broadband light generated by a lamp is passed through expensive spectroscopy to extract the far UVC wavelength needed for sensing applications. Nitrate (NO_3) and Nitrite (NO_2) absorb various levels of far UVC light based on their wavelength. A narrow band light emitted at a peak wavelength under 240nm is suitable for this application. Silanna's SF1 series of UVC emitters with peak wavelength under 235nm and a Full-Width-Half-Max (FWHM) of 10nm makes them an ideal candidate for nitrate sensing applications with currently available technology.

The nitrate sensing reference design is developed to demonstrate Silanna's SF1 LED capabilities. It can measure the dissolved Nitrate in units of mg/L-N, otherwise called PPM of Nitrogen in nitrate, and for the purpose of demonstration Standard solution (Nitrate Ion 300ppm)[iii] is dissolved in deionised (DI) water. This design utilises Silanna's 235nm emitter in a parabolic lens package (SF1-3U8P3L1) that produces a quasi-collimated far UVC beam of light as the light source. This light then passes through the liquid sample and the amount of light absorption determines the Nitrate concentration in the sample. To ensure high accuracy, the dosage of the emitted light is measured and is used to calculate the precise level of dissolved nitrate even at very low levels.

3. Concept and Design

The demo module is housed inside a light enclosure as shown in Figure 1. The lid at the back allows the user to access the quartz cuvette (Thorlabs CV10Q14[iv]) that holds the sample liquid. A capacitive touch display provides a user interface for ease of operation. The control system utilises a microcontroller to perform closed-loop control. The module is powered using 12VDC.

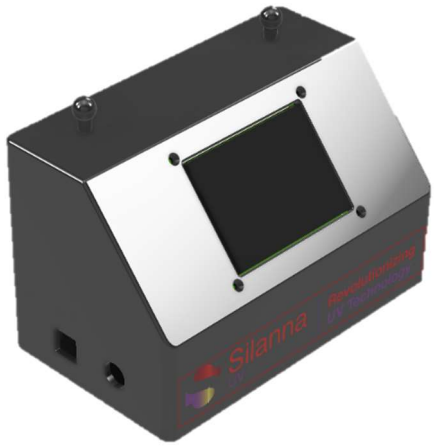

Figure 1: Nitrate Sensor Module

This nitrate sensing module demonstrates one of many applications of SF1 UVC emitter using Silanna's SF1-3U8P3L1 235nm parabolic lensed emitter. In this module, a control system delivers power to the emitter. It monitors and maintains the LED output level for a short duration of 500mS. This extremely short constant power pulses can be repeated under 1% variation over 3000 pulses. The amount of light transmitted through the solution is proportional to the amount of nitrate present in the solution. Additional wavelengths are generally used to compensate for absorption by other components, but in this demo, the use of standard nitrate solution in DI water eliminates the absorption by other materials.

The control system used in this demo has an 8-bit microcontroller that controls sub-modules such as the emitter controller, capacitive touch display, and receiver through an SPI communication bus. The microcontroller monitors the LED light output from the Reference photodetector (Hamamatsu S15289) and

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runs an algorithm based on various parameters to maintain the power to the SF1 emitter at a steady state. The transmitted signal is measured using the Transmittance photodetector (Hamamatsu S15289). With the given optical setup and the known level of UVC light emitted, the transmittance of the solution is determined. When the concentration of the contaminant in the solution changes, the signal measured by the secondary photodiode changes at a known proportion. The receiver sub-module accurately measures the transmittances, and the microcontroller calculates the concentration of the nitrate at a resolution of 0.01mg/L-N. The system is designed to compensate for the ambient temperature variations in laboratory conditions. Upon issuing the measurement command, the transmittance can be measured and displayed on the LCD screen instantly. Given the nature of UVC and the other electronic components, the system has the capability to measure at a very short repetition rate of 1 measurement per min.

In addition, this carefully engineered reference design compensates for thermal effects on the emitter due to its self-heating along with the ambient temperature variation. One of the main advantages of this approach is that it has the ability to make this measurement within 500mS, thus eliminating the requirement of LED warm-up time. This saves the useful lifetime of the emitter and other optics in the system, enabling 100k+ measurements with a single SF1 emitter. The 30D parabolic lens package, which generates the quasi-parallel beam of UVC light, eliminates the need for secondary optics, making the system more compact and cost-effective. The below table shows the specifications of this reference design.

To eliminate the risk of accidental exposure to UVC radiation, the light enclosure uses a safety interlock to instantly terminate the LED power supply when the cuvette cover is open.

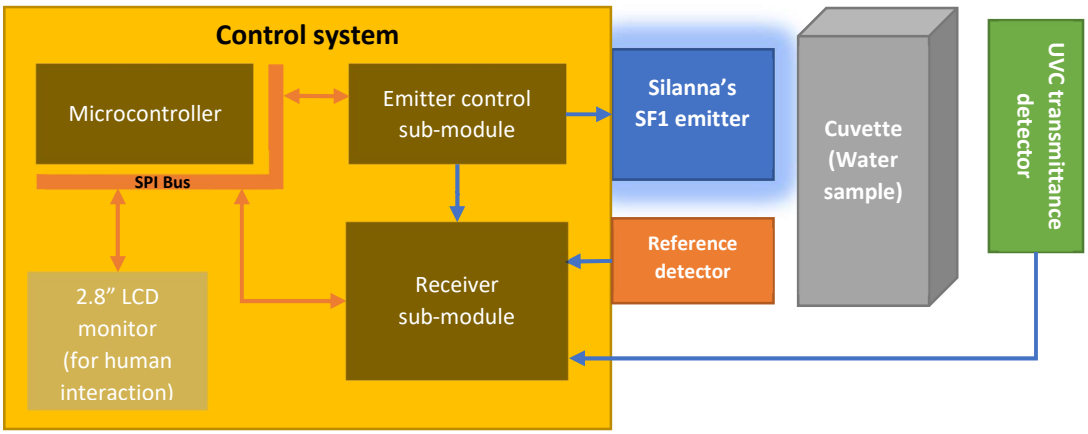

Figure 2: Nitrate Sensor Reference Design using Silanna's 235nm LED

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Specification[1]

Parameter	Specification
Parameter Measured	Dissolved nitrate
Measurement Range	0-10 mg/L-N
Coefficient of Variation (Repeatability)	<1% for 3000 measurements
Resolution	0.01 mg/L-N
Operating Temperature	20 – 30°C
Measurement Speed	500 mS (including warmup)
Accuracy	±0.6 mg/L-N
Light Source	235nm LED SF1-3U8P3L1
Measurement Medium	DI water in cuvette
Optical Path	10mm
LED Lifetime	>100k measurements
Dimension (mm)	166 (L) x 96 (D) x 120 (H)
User Interface	2.8” capacitive touch screen
Power Supply	12VDC wall adapter
Peak Operating Power	3W

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[i] https://www.epa.gov/nutrient-policy-data/estimated-nitrate-concentrations-groundwater-used-drinking
[ii] https://www.health.state.mn.us/communities/environment/water/contaminants/nitrate.html
[iii] https://www.horiba.com/int/products/detail/action/show/Product/standard-solution-nitrate-ion-300ppm-y042-1185/
[iv] https://www.thorlabs.com/thorproduct.cfm?partnumber=CV10Q14

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